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SCIENCE ABSTRACTS

SECTION A.—PHYSICS.

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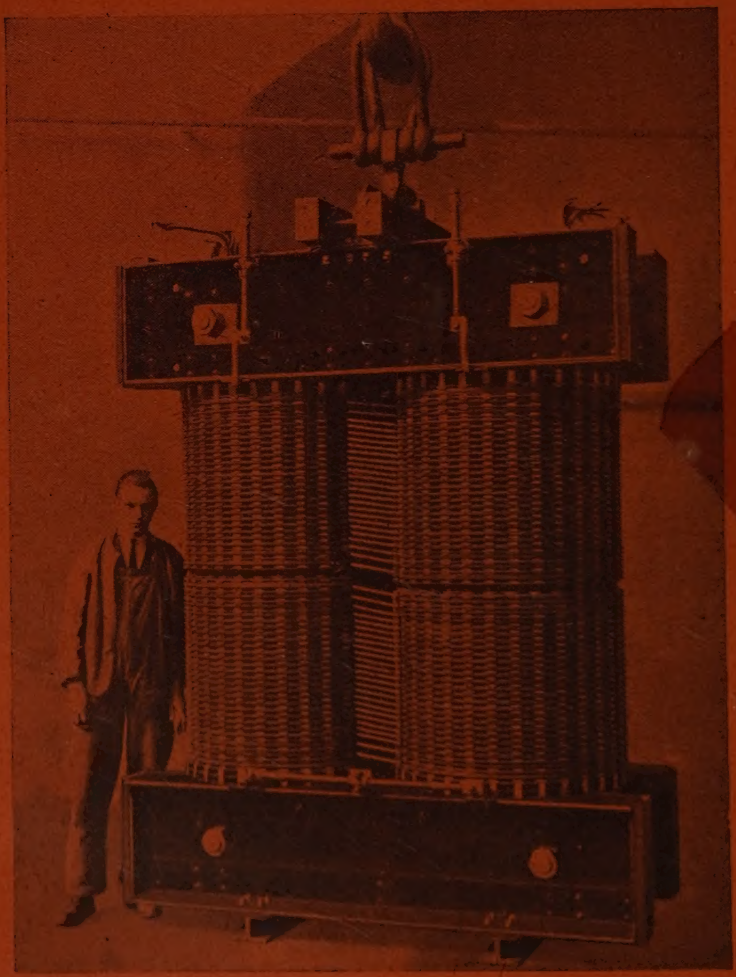

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

FEBRUARY 1923.

GENERAL PHYSICS.

116. *Problems of Quantum Theory in the Light of the Theory of Perturbations.* **P. S. Epstein.** (Phys. Rev. 19. pp. 578–608, June, 1922.)—It is shown that the physical purport of *Delannay's* method in the theory of perturbations consists in successive approximation of a given motion by means of a set of conditionally periodic motions. It is further shown, that at every degree of approximation two possible cases must be taken into account. In the one the motion of the system is periodic with respect to a certain variable, in the other this variable performs a libration.

AUTHOR.

117. *Sizes of Water-Drops in Clouds and Condensation.* **H. Köhler.** (Meteorolog. Zeits. 38. pp. 359–365, Dec., 1921.)—This is one of a number of papers in which the author is presenting the results of his practical researches into the condensation of water in the atmosphere, carried out at a high-level station in Scandinavia. The present paper deals with the sizes of water-drops deduced from observations of certain optical effects associated with a strong source of light, and also by microscopic measurements of drops deposited on fine wires. It is found that they tend to group themselves round certain radii, suggesting that, after a certain size is reached, growth takes place mainly by coalescence, and that, in general, an even number coalesce. A well-marked group is the " 7-group " with radii $A_1 = 7 \times 10^{-4}$ cm., $A_2 = 9 \times 10^{-4}$ cm., $A_4 = 1{\cdot}1 \times 10^{-3}$ cm., $A_8 = 1{\cdot}4 \times 10^{-3}$ cm., $A_{32} = 2{\cdot}2 \times 10^{-3}$ cm. Two drops of size A_1 form one of size A_2, four form A_4, eight A_8, and thirty-two A_{32}. Other similarly constituted groups may occur, in particular an " 8-group," and drops of different groups may coexist in the same cloud.

The question is asked—with what size of drop does growth by coalescence commence? The direct observations do not answer this completely, but other considerations, in conjunction with them, lead to the conclusion that drops as small as $1{\cdot}7 \times 10^{-5}$ cm. can hardly coalesce, but drops of radius $3{\cdot}6 \times 10^{-4}$ cm. may grow by that means, even to the size of rain-drops.

Other points are that drops can probably increase to a radius of $1{\cdot}5 \times 10^{-3}$ without coalescing; that in winter and summer, with tempera-

ture above or below 0° C., the clouds observed were mainly water-clouds; that water-drops may coalesce below 0° C. without freezing; in general they begin to freeze at $1{\cdot}5 \times 10^{-3}$ cm. M. A. G.

118. *Discussion on the Horizontal Range of Vision as a Meteorological Observation.* (Roy. Meteorolog. Soc., J. 48. pp. 85–113, April, 1922.)—**F. J. W. Whipple**, in opening the discussion, gives a brief history of visibility observations, followed by remarks (1) on the theory of contrast, by which an object is seen, by contrast with its background, the better the smaller the amount of light reaching the observer due to reflection or diffraction by the air between him and the object; (2) on the terms haze, mist, and fog; (3) on Aitken's researches into the relation of visibility to the state of the atmosphere; (4) on nuclei of condensation, in which the opinion is expressed that a dense London fog is to be regarded as the product of coexisting but physically independent smoke and water fogs, the former not influencing the density of the latter by providing nuclei of condensation; (5) on the practical observation of visibility by selecting, at each station, suitable standard objects, and on the telegraphic code for reporting the observations to a central office. Finally an analysis is given of observations during 1920 and 1921 at 16 stations distributed over the British Isles, bringing out the diurnal and annual variations and contrasting conditions in different parts of the country.

D. Wilson-Barker deals with visibility at sea. In addition to fog the most serious difficulty, mist and falling rain or snow, deterioration of visibility due to "dust-haze," *e.g.*, off the African Coast, may be of practical importance, as may that due to "spoondrift," i.e. spray during gales, and also haziness due to "milky sea" in the Indian Ocean.

M. G. Christie, from the airman's point of view, deals with the deterioration of vertical visibility by fog, mist, and cloud as affecting landing, aerial navigation, and photography from the air.

J. S. Owens separates out the conditions on which visibility depends under the headings (*a*) physical and (*b*) physiological, and then proceeds to arguments in favour of his contention that one of the chief factors governing visibility is the presence of suspended matter in the air other than water. The factors under (*a*) are illumination of object and surroundings, contrast of light and shade, colour, form, and medium through which light is transmitted, and under (*b*) the sensitiveness of the human eye to light and shade, variation of sensitiveness with illumination, power of perception of different colours, and perception of image on retina (affecting, *e.g.*, visibility of flashes).

Other contributions were made as follows:—**C. K. M. Douglas** (particularly vertical extent of haze); **W. Peddie** (experiments with instruments for measuring transparency); **W. D. Laing** (suggested scale for recording visibility); **A. G. Lowndes** (effect of polarisation on visibility); **C. Harding** (discussion of observations of fog at sea); **H. P. Waran** (visibility and astronomical work); **L. C. W. Bonacina** (visibility and luminosity; apparent "nearness": heterogeneous distribution of London fog); **J. E. Clarke** (summary of visibility observations made at three points in London since 1906).

N. Shaw, in summing up, emphasises particularly the distinction between visibility in the air and visibility of the ground "from the air"; also the importance of aspect, there being, *e.g.*, a great difference between visibility up and down sun. M. A. G.

119. *Photogenic Action of the "Ultra-Radiations."* **A. Nodon.** (Comptes Rendus, 174. pp. 1061–1062, April 18, 1922.)—A very brief note describing the author's practical demonstration of the photogenic action of certan very penetrating radiations emanating from the sun and the upper atmosphere, to which reference has been made in an earlier note. M. A. G.

120. *On Fluid Motion Relative to a Rotating Earth.* **G. Green.** (Phil. Mag. 44. pp. 53–62, July, 1922.)—An investigation of the conditions under which the circulation theorem may be applied to atmospheric motions relative to the earth's surface. W. R. C.

121. *Results of Recent Earth-Current Observations and Relations with Solar Activity, Terrestrial Magnetism, and Atmospheric Electricity.* **L. A. Bauer.** (Terrest. Magn. 27. pp. 1–30, March–June, 1922. Paper read before the Philosoph. Soc., Washington, Feb., 1922.)—As a preliminary to systematic observations of earth-currents in different parts of the world, planned by the Department of Terrestrial Magnetism of the Carnegie Institution (of Washington), a discussion was undertaken of existing data, particularly a series of observations of earth-currents, terrestrial magnetism, and atmospheric electricity at the Observatorio del Ebro, Tortosa, Spain, extending over a complete sun-spot cycle of 11 years. The present paper sets out the results derived from observations on magnetically-calm or electrically-calm days, and a further paper will probably deal with results for disturbed days.

Amongst other results, little support is found for the hypothesis often advanced that the earth's magnetic field is caused by electric currents circulating in the crust. A comparison of the annual variation (as well as of the diurnal variation) of earth-currents and terrestrial magnetism shows that the former cannot be related directly to the latter, except in a minor degree, as cause and effect, though they may be related to common causes. The N.-S. component of the earth-current might, however, be the result of electro-magnetic induction, caused by fluctuations, during the day, of the W.-E. component of the earth's magnetism. M. A. G.

122. *Periodic Fluctuations of Convection Currents with a Hint on the Origin of Sun-Spots Cycle.* **T. Terada.** (Phys. Math. Soc. Japan, Proc. 4. pp. 162–169, Sept., 1922.)—Several years ago, while testing the constancy of the zero point of a sensitive balance, T. Matoba and Z. Kobayasi observed a peculiar periodic fluctuation of the zero point. Experiments confirmed the phenomenon to be due to convection currents set up within the glass case, and from the observations then made the present author was led to consider if a similar periodic fluctuation of convection current could not be found in nature, *e.g.*, in the atmosphere. He has now followed out an idea that the periodicity of solar activities may be connected somehow with the fluctuation of some convection system in the solar atmosphere. This theory is discussed mathematically in the paper, and application to the case of the balance has produced reasonable results as regards order of magnitude. A similar application, however, to the atmosphere, has shown its inadequacy for explaining any observed fluctuation of the terrestrial convection system such as land and sea breezes, monsoon, etc., which appear to be not of the character here considered, but probably of purely dynamical origin as ordinarily believed. A discussion of the solar

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atmosphere then follows, but development of the idea is impeded by lack of the necessary data, although the author hopes it will prove of interest as an attempt to connect the origin of the periodicity directly with the probable cause of the law of rotation of the solar atmosphere. H. H. Ho.

123. *Rotation of Sun's Reversing Layer.* **J. Halm.** (Roy. Astron. Soc., M.N. 82. pp. 479–483, June, 1922.)—The intention was to test whether the sun's rotation varied during the cycle of solar activity. The material employed consists of Dunér's observations at Upsala, 1887–1889 and 1899–1901; the author's at Edinburgh, 1901–6; Adams's at Mount Wilson, 1906–7 and 1908; those of Storey and Wilson at Edinburgh, 1909, and of Plaskett and De Lury at Ottawa, 1911, 1912 and 1913. It is shown that the results at Edinburgh, Upsala, and Mount Wilson are in close agreement when comparison is possible at the same epoch, and so the whole of the results are considered comparable. The rotation in different latitudes shows a general parallelism, but there is a decided variation with sun-spot period phase of which a diagram is given. A table is added giving the linear rotation velocities for every 5 degrees of latitude from the solar equator to 80° for the different epochs and observatories. The result definitely denies the possibility of a constant law of rotation. W. W. B.

124. *Dominion Astrophysical Observatory, Victoria, B.C.* (Dom. Astrophys. Observat. Victoria, Publ. No. 26. Vol. I. Nature, 110. p. 189, Aug. 5, 1922.)—This issue gives a list of 88 new spectroscopic binaries discovered since the first 100 announced in No. 10. The spectrograph is mounted on the 72-inch reflector, used as a cassegrain, with equivalent focal length 100 feet. 90 per cent. of the stars belong to types B, A, and F. Half the B stars are binaries, so that it may be that all stars at this stage are binaries. The following star of $\epsilon 1890$ (3″·5) is on the list, the preceding star having a fixed velocity. Another is Boss 4777, the distant (46″) companion of β Ayræ. W. W. B.

125. *Partial Explanation, by Wave-Lengths, of the K-Term in the B-Types.* **S. Albrecht.** (Astrophys. J. 55. pp. 361–369, June, 1922.) —*K-Term of the Radial Velocity of Class B Stars.*—Whether the K-term is due to an expanding universe, to causes within the stars, or to the Einstein effect, it is of importance to determine the part due to the use of inaccurate normal wave-lengths in the reductions. For most of the lines upon which the B-type velocities are based, such as those of Si and He, sufficiently accurate wave-lengths are not available; but in the case of twenty O and N lines, new wave-lengths by Clark are found to be systematically 0·063 Å. longer than the adopted normals. A discussion of the available portions of the data on which the K-term is based, indicates that the new wave-lengths for this one group of lines alone would reduce the K-term, which is about 4 km., by about 0·3 km. for the entire B class and by about 0·8 km. for classes B0–B2.

Test of the Relative Accuracy of Groups of Wave-Length Normals.—Since the spectra of different classes of stars are radically different, it is suggested that a comparison of the mean wave-lengths for the lines which these classes have in common might give evidence as to the relative accuracy of the principal group of normals involved in each case. For instance the wave-lengths of types B0–B2 are based more on O, N, and

Si lines than those of types B3–B5, and they are systematically 0·015 A shorter. AUTHOR.

126. *Effective Wave-Lengths of* 129 *Stars within* 0·05 *of the North Pole and of the* Σ *Companion of Polaris.* **E. Hertzsprung.** (Mt. Wilson Observat. Contrib. No. 231. Astrophys. J. 55. pp. 370–379, June, 1922.)—The results of measurements of about 500 images on 12 plates (Lumière Σ) taken in 1912 with the 60-inch reflector and a grating whose constant was 6 mm., are given. AUTHOR.

127. *Trigonometrical Parallaxes of* 22 *Cepheids.* **S. A. Mitchell.** (Observatory, 45. pp. 294–296, Sept., 1922.)—These parallaxes have been measured at the Leander McCormick Observatory on plates taken with the 26-inch refractor. The spectroscopic method employed at Mt. Wilson is not independent, but must ultimately rely on accurate trigonometrical parallaxes, hence the value of the work done in Virginia, these dependent on a background of tenth magnitude stars, so that for comparison purposes a parallax of 0·″005 is assumed for these. Comparison with the spectroscopic parallaxes of the same stars shows that they are very near the truth. W. W. B.

128. *Parallaxes of Open and Moving Clusters.* **P. Doig.** (Roy. Astron. Soc., M.N. 82. pp. 461–466, June, 1922.)—Of the three chief methods of estimating the distances of open clusters—(1) from proper motions of individual stars combined with spectroscopical radial velocities, (2) from luminosity curves on the assumption that these are the same for clusters as for space generally, (3) from probable absolute magnitudes based on empirical relationships between luminosity and spectral class—having regard to the distinction between giants and dwarfs, the author shows that method (2) gives distinctly larger parallaxes than method (1), and considers that method (3) is at least as good as (2). He applies this method (3) to the Perseus cluster, the Coma Berenicis cluster, the Taurus group, the Pleiades, and Præsepe. These agree fairly well with those obtained by method (1), and he infers that method (2) gives parallaxes about four times too great. There remains the uncertainty of the luminosity curve, which depends too much on selected observations. It is also possible that the curve for clusters is different from the general curve. W. W. B.

129. *Parallaxes of Stars in the Region of B.D.* + 31°643. **C. H. Gingrich.** (Mt. Wilson Observat. Contrib. No. 239. Astrophys. J. 56. pp. 139–144, Sept., 1922.)—*Diffuse, Irregular Nebula, and Stars Around B.D.* + 31°643.—A photograph made by Hubble with the 100-inch reflector is reproduced. From a series of plates taken by van Maanen with the 60-inch reflector, the parallaxes and proper motions of 20 stars, with reference to six or seven among them which appear not to be related to the nebula, were determined. Five of these have *colour-indices* from 0·74 to 0·95 in excess of normal and seem to be involved in the nebula. The mean of the parallaxes of these five stars is 0″·0095 ± 0″·006. This is therefore taken to be the *parallax of the nebula,* equivalent to a distance of 350 light years from the sun. AUTHOR.

130. *A Spectroscopic Method of Determining the Absolute Magnitudes of A-Type Stars and the Parallaxes of* 544 *Stars.* **W. S. Adams** and **A. H.**

Joy. (Mt. Wilson Observat., Contrib. No. 244. Astrophys. J. 56. pp. 242–264, Nov., 1922.)—In order to ascertain whether a spectroscopic method could be applied to these stars, spectrograms were obtained of nearly all the A-type stars in the Taurus and Ursa Major groups, fifty-six in all, whose absolute magnitudes are accurately known. The stars were then grouped (*a*) according to spectral type and (*b*) according to whether the lines were diffuse or sharp. A good correlation between magnitude and spectrum was found, the magnitude being brighter the earlier the spectral type and also brighter for spectra with sharp lines. The study was then extended to include all A-type stars for which both the spectral type and parallax were known, and the same correlation was found, the average difference being only $\pm 0''{\cdot}0077$ for eighty-two parallaxes determined by group motion, and $0''{\cdot}0131$ for 104 trigonometric parallaxes. The accuracy of parallax determinations by this method for A-type stars is thus of the same order as for stars of later types, and the method is evidently capable of considerable further refinement. Spectroscopic parallaxes of 544 stars of type B7 to F2, determined on the basis of the foregoing results, are given. When grouped according to their proper motions, the mean parallax of each group is found to increase from $0''{\cdot}011$ for $\mu < 0''{\cdot}010$ to $0''{\cdot}037$ for μ about $0''{\cdot}2$. AUTHOR.

131. *An Estimate of the Distance of the Andromeda Nebula.* **E. Oepik.** (Astrophys. J. 55. pp. 406–410, June, 1922.)—Assuming the centripetal acceleration at a distance r from the centre is equal to the gravitational acceleration due to the mass inside the sphere of radius r, an expression is derived for the *absolute distance* in terms of the linear speed v_0 at an angular distance ρ from the centre, the apparent luminosity i, and E, the energy radiated per unit mass. From observations, v_0 comes out 157 km./sec. for $\rho = 150''$; and giving i a value corresponding to magnitude 6·1, and assuming E the same as for our galaxy, the distance is computed to be 450,000 parsecs. This result is in agreement with that obtained by several independent methods. If it is correct, the mass within $150''$ of the centre is about $4{\cdot}5 \times 10^9$ times the sun's mass, and the nebula is a stellar universe comparable with our galaxy. The ratio of the axes of the central ellipsoid, whose shape is supposed to be due to rotation, was determined from photographs to be about 0·79. AUTHOR.

132. *Light Changes and other Peculiarities of Nova Persei No.* 2 (1901). **E. E. Barnard.** (Roy. Astron. Soc., M.N. 82. pp. 457–461, June, 1922.)—This is a continuation of previous measures [see Abs. 1259 (1920)] up to a sudden decline in magnitude at the end of March, 1922. The sudden changes noted from time to time are real, but the star shows a tendency to keep fairly bright on the whole. It is more stellar in appearance than Nova Aquilæ (3) and Nova Cygni (Denning). Its position cannot be measured with precision on account of the absence of near comparison stars. The observations given extend from 1920, September 10, to 1922, April 15. W. W. B.

133. *A very Massive Star.* **J. S. Plaskett.** (Roy. Astron. Soc., M.N. 82. pp. 447–457, June, 1922.)—This was discovered in the course of an examination of all known Oe and Oe 5 stars within reach of the spectroscope of the Dominion Astrophysical Observatory, Victoria, B.C. The type of this star, B.D. + 6° 1309, appears to resemble both Oe and Oe 5 in some details and is probably intermediate between them.

Details are given of the indentification of lines, and the spectroscopic orbit deduced from the relative shifts. The period is about 14·4 days, so that the distance between the components is comparatively large. The probable masses and the absolute magnitude are also computed. The H and K calcium lines are stationary, so there may be a fixed calcium cloud in the line of sight. The derived dimensions of the system are thus summarised :—It consists of two very bright Oe stars, 10,000 light-years away, revolving around one another in a period of 14·414 days at a separation of some 90 million km. The brighter star has a probable mass at least 86 times that of the sun, a density of 1/100 and absolute magnitude −5·65. The fainter has a mass of 72, the same density and absolute magnitude −5·4, that of the system being −6·3, the greatest known. The velocity of the system is + 23·9 km. and of the Ca vapour + 16·0 km., a difference too great to be explained by relativity displacement. W. W. B.

134. *Four Interesting Nebulæ.* **C. D. Perrine.** (Roy. Astron. Soc., M.N. 82. pp. 486–491, June, 1922.)—N.G.C. 1291 is not a globular cluster, but probably a spiral nebula of exceptional interest, the outer ring forming one and a half turns of a helix, while the space between this outer ring and the central condensation shows some evidence of dark material. N.G.C. 4027 and 4038–9 are also spirals, though the former is listed in N.G.C. as a globular cluster and the latter is divided into two. N.G.C. 6822 resembles the Magellanic clouds, and appears to be farther away than the apparent background. N.G.C. 6935–7 are two very similar objects close together almost more exactly alike than the two portions of N.G.C. 4038–9 and 4027. The second of the two is fainter, and they appear to be spiral rather than planetary. Further observation is required which cannot be made yet. An addendum refers to independent observations of all but the last pair of the foregoing, either at Helwân Observatory or Mount Wilson. The descriptions agree quite well with those at Córdoba. W. W. B.

135. *System of Castor.* **W. Rabe.** (Astron. Nachr. Nos. 5164 and 5165. Nature, 110. p. 189, Aug. 5, 1922.)—The author gives the following elements for Castor : $a = 6''{\cdot}06$, $e = 0{\cdot}5593$, $i = 66°{\cdot}79$, $\omega = 81°{\cdot}97$, $\Omega = 32°{\cdot}55$, $T = 1954{\cdot}73$, and Period = 306·28 years, with a probable error of 5 years. This agrees closely with the minimum ellipse given by Lewis in his memoir on the Struve double stars. Burnham's vague suggestion that the fainter star has a close unseen companion with an 8½-year period is supported by spectroscopic observations. The parallax of the system is given as $0''{\cdot}0745$. The deduced mass of the system is 5·74 times that of the sun, of which 3·33 belongs to the brighter star and 0·60 to the third star, if real.

Both the visible stars are spectroscopic binaries, and it had been suggested from the measures of radial velocity that the fainter star was the more massive, on the assumption that both spectroscopic orbits were in the plane of the principal orbit, which Rabe shows to be improbable. A distant companion also belongs to the system, making at least six members. Rabe gives proper motion of the centre of gravity of the system $-0''{\cdot}0134$ in R.A. and $-0''{\cdot}108$ in Decl. The deduced true velocity is 10·46 km.-sec. towards R.A. 305°·5 Decl. + 42°·5, agreeing with that of a group of 22 A stars of Drift I discussed by H. C. Plummer. W. W. B.

136. *Revised Magnitudes for Stars near the North Pole.* **F. H. Seares.** (Mt. Wilson Observat. Contrib. No. 235. Astrophys. J. 56. pp. 97–118, Sept., 1922.)—*Revised Magnitudes and Colour-Indices for Stars near the North Pole.*—Numerous comparisons with the polar standards have incidentally given extensive material for determining the errors affecting the standards themselves. The results for 55 stars lead to revised magnitudes which are averaged with previously reported results.

Exposure-ratio method of determining colour-indices has been previously described. A discussion of the results of 177 exposures, including stars of photo-visual magnitude ranging from 2 to 17·3, indicates that the average deviation of a single determination is $\pm$ 0·12 magnitude, about half of which is due to the mean systematic error of the plate, and that in general the probable error is about 30 per cent. less than in the case of a colour-index derived by combining a photographic and a photo-visual magnitude. Normal points for the calibration curve, colour-index as a function of log E, determined by observations on 216 stars, are given.

Differential Error between Photo-Visual and Photographic Scales of Magnitude.—Although the exposure-ratio colour scale is calibrated by measurements on stars of known colour-index, systematic errors in the two magnitude scales upon which the colour scale depends were eliminated by using stars with a wide range of magnitude. Hence the exposure-ratio scale is independent of the magnitude scales and may be used to test the differential error between them. The data show agreement to within $\pm$ $0^{M}.03$ from photo-visual magnitude 3 to 17, except for a few stars near magnitude 9 for which the mean difference is $0^{M}.09$. AUTHOR.

137. *Further Evidence on the Brightness of the Stars of the North Polar Sequence.* **F. H. Seares** and **M. L. Humason.** (Mt. Wilson Observat. Contrib. No. 234. Astrophys. J. 56. pp. 84–96, Sept., 1922.)—*Mount Wilson Photographic and Photo-Visual Scales of Magnitude.*—These scales were based wholly on plates made with the 60-inch reflector, and as there was some question as to photographic magnitudes brighter than the tenth, and photo-visual magnitudes fainter than the eighth, additional data have recently been secured with the 10-inch Cooke refractor. Exposures both with and without a wire screen which absorbs 3·02 magnitudes were made on 54 plates. Taking the photographic magnitude of each star to be $0^{M}.19$ C less for the 10-inch than for the 60-inch, where C is the colour-index, and the photo-visual magnitude to be the same for both, the investigation reveals no appreciable error in the photographic scale and shows it to be homogeneous from the fourth to the fourteenth magnitude; and the slight correction of + $0^{M}.05$ indicated for the photo-visual scale near the ninth magnitude is not confirmed by more reliable exposure-ratio results to be reported elsewhere. The original scales are therefore retained.

Revised Magnitudes of Stars of the Polar Sequence.—The plates also enable corrections to be given to the photographic magnitudes of 45 stars and to the photo-visual magnitudes of 28 stars. These average $\pm$ $0^{M}.03$ and $\pm$ $0^{M}.04$, respectively, for the two scales. The larger photographic corrections are in substantial agreement with those recently found at Greenwich by Jones. AUTHORS.

138. *The Variable Double Star X Ophiuchi.* **C. H. Gingrich.** (Mt. Wilson Observat. Contrib. No. 238. Astrophys. J. 56. pp. 132–138, Sept., 1922.)—From direct measurements by Hussey and later by van Biesbroeck it is known that the two components of this interesting system are about $0''\cdot22$ apart and were in a nearly north and south line in 1921, and that the north component is variable. During 1921 van Maanen made 16 plates to determine the parallax, which came out $0''\cdot000 \pm 0''\cdot007$. These plates have since been measured in declination to see whether any *displacement of the combined image* due to the variation in relative brightness of the components could be detected. With reference to exposures made near a maximum of the combined light, a mean displacement of about $0\cdot''15$ to the south was found for a group of eight exposures made about midway between maximum and minimum. This result is in agreement with the previous conclusions mentioned above. On the plates measured there was no evidence of elongation of the image. AUTHOR.

139. *The Eclipsing Binary σ Aquilæ.* **C. C. Wylie.** (Astrophys. J. 56. pp. 232–241, Nov., 1922.)—A series of 97 observations with a photo-electric photometer during 1920 gives an accurate light-curve of this fifth-magnitude star. It is found to be a normal eclipsing system with two minima and continuous variation, due to ellipticity, between eclipses. The range of variation is $0^{M}.18$; the period is $1^{d}.95026$. *Comparison star* 22 *Aquilæ* was constant within $0^{M}.01$ or $0^{M}.02$ from July to October 1920, but between 1918 and 1920 the observations indicate a change of $0^{M}.02$ for either 22 Aquilæ or σ Aquilæ. AUTHOR.

140. *The Cepheid Variable η Aquilæ.* **C. C. Wylie.** (Astrophys. J. 56. pp. 217–231, Nov., 1922.)—A series of 111 observations made with a photo-electric photometer during 1920, gives an accurate light-curve of this 4th magnitude star. The range of variation is $1^{M}.12$; the period is $7^{d}.176$. The "secondary maximum" is confirmed as a pronounced halt in the decrease of light, from phase $1^{d}.8$ to $2^{d}.4$. Another fluctuation was indicated with maximum about phase $4^{d}.3$. The increasing period of η Aquilæ, which is contrary to the requirement of the *pulsation theory*, and the decreasing period of δ Cephei can perhaps be reconciled on the basis of the binary theory by assuming that η Aquilæ rotates relatively faster than δ Cephei. AUTHOR.

141. *Stellar Luminosities.* **H. D. Curtis.** (Astron. Soc. of Pacific Publ. Feb., 1922. Roy. Astron. Soc. Canada, J. 16. pp. 209–217, July–Aug., 1922.)—After defining absolute magnitude and the scale of magnitude in general use, the author considers the validity of parallax results available. He includes certain classes, such as Cepheids, and includes comparatively few heliometer parallaxes, and none determined with meridian circles. The data left for his purpose gives him 2375 stars, including the absolute magnitudes determined by Adams and his associates, and the hypothetical parallaxes of double stars by Jackson and Furner. The diagram of resulting absolute magnitudes for classes B, A, F, G, K, and M ranges from magnitude − 4 to + 15, and shows the division into giants and dwarfs beginning about class G5, different kinds of dots denoting different modes of determination. The results emphasise the

average character of the sun among stars in general, since the double stars fit in so well, and in their case the assumption is made for each pair that the combined mass is twice that of the sun. The author considers the question of the few negative parallaxes that crop up, and explains them by the presence of unidentified later type dwarf stars among the comparison stars employed. He gives a table of the probable value of the parallax of a 9·5 magnitude star of types A5, F5, G0, K0, and K5 respectively, the last two having two values, according as they are giants or dwarfs. He proposes a special campaign in the direction of the early B stars, which is to be undertaken at Allegheny and at the Leander McCormick Observatory. The stars of types K and M he thinks have already had more than their share of attention, and suggests that it will be better for a time to devote more time to the brighter stars, such as those of Boss' Preliminary General Catalogue. W. W. B.

142. *Changes in the Spectrographic Elements of Y Sagittarii.* **J. C. Duncan.** (Mt. Wilson Observat. Contrib. No. 248. Astrophys. J. 56. pp. 340-343, Nov., 1922.)—A velocity curve of this Cepheid variable, derived from 17 single-prism spectrograms made at Mount Wilson and three triple-prism spectrograms made at Mount Hamilton in 1921, is compared with the curve derived from 26 single-prism spectrograms made at Mount Hamilton in 1908. Elliptic elements for both years are given. The velocity of the system is found to have changed from + 3·6 to − 5·9 km./sec., while the eccentricity in 1921 appears to be double its value in 1908. Other elements also seem to have changed, but less markedly. AUTHOR.

143. *Study of Diffuse Galactic Nebulæ.* **E. Hubble.** (Mt. Wilson Observat. Contrib. No. 241. Astrophys. J. 56. pp. 162-199, Oct., 1922.)—A classification is suggested based upon the fundamental differences between galactic and non-galactic nebulæ. Galactic nebulæ are subdivided into planetary and diffuse (luminous and dark), and non-galactic into spiral, elongated (spindle and ovate), globular and irregular. The characteristics of each are discussed. The distribution of diffuse nebulæ is considered, and spectral characteristics. The author deduces the view that the nebulosity seems to consist of clouds of matter, molecules, dust, or perhaps larger particles, not hot enough to be self-luminous, but visible because of light excited by or reflected from involved or neighbouring stars. AUTHOR.

LIGHT.

144. *On Reflection from a Moving Mirror and the Michelson-Morley Experiment.* **E. H. Kennard** and **D. E. Richmond.** (Phys. Rev. 19. pp. 572–577, June, 1922.)—Formulæ for the direction and speed of the reflected wave with reference to the moving system are derived. The angle through which a ray is deviated by a moving mirror contains a second-order term in v/c, which it was thought by Righi would account for the negative result of this experiment. In the present article, the relative *ray-paths* through the interferometer are traced, the phase difference is calculated and the *interference pattern* is obtained, and it is found that the second-order term produces only an imperceptible alteration in the fringe pattern. It is concluded, therefore, in agreement with Villey, that the usual interpretation of the experiment in favour of relativity still holds. AUTHORS.

145. *The Variation of the Index of Refraction of Water, Ethyl Alcohol, and Carbon Bisulphide, with the Temperature.* **E. E. Hall** and **A. R. Payne.** (Phys. Rev. 20. pp. 249–258, Sept., 1922.) *Index of Refraction of Pure Water for Sodium Light from 15° to 100° C.*—Very few observations had previously been made for temperatures above 50° C. A precision spectrometer was used. The brass prism with optical glass windows was gold plated inside to prevent contamination of the pure gas-free water tested, and means were provided for keeping the temperature within 0·1° C. Many readings were taken and the average values are probably accurate to within about 0·00002. When reduced to vacuum they are well represented by the empirical formula:

$$n = 1{\cdot}33401 - 10^{-7}(66t + 26{\cdot}2t^2 - 0{\cdot}1817t^3 \times 0{\cdot}000755t^4).$$

The temperature coefficient dn/dt changes from $-8(10)^{-5}$ at 15° to $-30(10)^{-5}$ at 100°.

Index of Refraction of Commercially Pure Ethyl Alcohol and Carbon Bisulphide for Sodium Light from 15° up to the Boiling-Points.—While Kahlbaum's ethyl alcohol, 99·8 per cent. absolute, and Baker's C.P. CS_2 were used, the absolute values obtained differ somewhat from those given by others for pure samples. The results correspond to the empirical equations:

$$dn/dt(\text{ethyl alcohol, 15 to 70°}) = -10^{-6}[404 + 0{\cdot}44(t - 15) + 0{\cdot}0075(t - 15)^2];$$
$$dn/dt(CS_2,\ 15 \text{ to } 45°) = -10^{-6}[766 + 5{\cdot}12(t - 15) - 0{\cdot}105(t - 15)^2].$$

AUTHORS.

146. *The Optical Constants of Sodium-Potassium Alloys.* **R. Morgan.** (Phys. Rev. 20. pp. 204–213, Sept., 1922.)—An entire alloy series was investigated by the polarimetric method. Bright metallic surfaces were obtained by filling glass cells with the molten metal in a vacuum. Excepting sodium, all the specimens were observed in the liquid form. In the region near the composition corresponding to NaK the refractivity-concentration curve has a maximum value of 0·137 and the absorptive index-concentration curve has a minimum value of 12·5. The effect of change in temperature was studied for some of the mirrors. The solid

alloy containing 83 per cent. Na showed a change in the optical constants with a change in temperature, but no change was found for the liquid alloy containing 26 per cent. Na. It could not be definitely determined whether the change observed for the solid alloy was due to a change in the optical constants or was due to a possible surface effect resulting from the metal expanding and making better contact with the glass.
AUTHOR

147. *Reciprocal Diffraction Relations between Circular and Elliptical Plates.* **J. Coulson** and **G. G. Becknell.** (Phys. Rev. 20. pp. 594–600, Dec., 1922.)—When a circular disc with its plane originally tangent to the light wave is rotated about an axis in its plane, the Arago spot changes to a figure with four cusps which move out along the axes of the elliptical shadow, two approaching the foci as limits and the other two going outside the shadow. The diffraction pattern was found by the authors to depend only on the ellipticity of the shadow whether produced by an ellipse or by an inclined disc. Each quadrant of the diffraction pattern was found to be associated with the quadrant of the shadow adjacent to it but on the opposite side of the major axis. Careful measurements of the photographs prove that in each case the diffraction pattern is the evolute of the geometrical shadow. The effect is as though each element of the edge of the shadow contributed a spot along its normal, the result being a caustic curve of diffraction. AUTHORS.

148. *An Extension of the Principle of the Diffraction Evolute, and some of its Structural Detail.* **G. G. Becknell** and **J. Coulson.** (Phys. Rev. 20. pp. 607–612, Dec., 1922.)—(1) *Conic Section Shadows.*—In confirmation and continuation of the results in the preceding abstract, the patterns, due to a point source, are found to depend only on the shape of the shadow, the Arago spot being obtained at the centre of the circular shadow even when this was cast by a spiral edge of large pitch ground to the form of a truncated cone, when the point source was placed at the apex. Patterns inside the shadows of hyperbolic and parabolic plates were also obtained and are reproduced. As in the case of the ellipse, the predominant figure in each case is the evolute of the edge of the shadow. (2) *This general relation between diffraction caustic and shadow* is found to hold even in the case of the shadow of the involute of a circle, when the diffraction figure was identical with the generating circle which was, of course, the evolute of the edge of the shadow. A series of photographs of elliptical shadows show that the diffraction caustics are not continuous curves. The changes of detail and of colour in the patterns with change of ellipticity of the shadow are described at some length. AUTHORS.

149. *Magnetic Rotation in Various Liquids in the Short Infra-Red Spectrum.* **L. R. Ingersoll.** (Optical Soc. America, J. 6. pp. 663–681, Sept., 1922.)—The magnetic rotation and refractive index of twenty pure liquids and as many aqueous solutions of metallic salts have been measured for the spectrum range between $0{\cdot}56\,\mu$ and $2{\cdot}3\,\mu$. Positively rotating liquids show a rotation very nearly proportional, in most cases, to the inverse square of the wave-length, indicating that infra-red absorption bands have small influence on the rotation in this region. The few negatively rotating liquids show a much greater rotation dispersion. This is nearly the inverse cube for titanium tetrachloride and concentrated ferric chloride solution, while for potassium ferricyanide solution it is almost

as the inverse fifth power of the wave-length. Values of e/m calculated from these measurements on positive liquids show in general a diminution for longer wave-length, as might be expected. Several types of curves may be distinguished in this connection. AUTHOR.

150. *The Effect of Changes of Surface-Curvature at the Focus of an Astronomical Object-Glass.* **E. W. Taylor.** (Optical Soc., Trans. 23. pp. 241–243; Disc., 244–245, 1921–1922.)—The correct balancing of the components of a large object-glass is necessarily a lengthy and difficult process and the effect, at the focus, of a similar alteration of curvature at each of the four surfaces is different. If the effect of an alteration at each of the four surfaces is known, the one most suitable may be chosen, having regard to the amount and nature of the aberration it is necessary to overcome. Practical paper, giving the experience of Messrs. T. Cooke and Sons. A. D.

151. *Geometrical Optics of Dispersion in Prisms.* **H. Opitz.** (Zeits. f. Physik, 10. 4. pp. 243–251, 1922.)—Dispersion phenomena in prisms are investigated by aid of the differential formula, $d\epsilon_1 = \sin\phi\, dn/\cos\beta\cos\epsilon_1$, and for obtaining the functional connection between the variables the incident angle has been varied. $\pi(\epsilon, \phi, n) = n\sin\phi/\Delta\Delta_1$ is then the dispersion function, where

$$\Delta = \sqrt{n^2 - \sin^2\epsilon}, \text{ and } \Delta_1 = \sqrt{1 - (\sin\epsilon\cos\phi - \Delta\sin\phi)^2}$$

[see Abs. 1400 (1915)]. The properties of this function give an excellent picture of the mechanism of dispersion phenomena. On account of computation difficulties, however, an amplified graphical method has been proposed, and despite the criticism of Erfle, it is now shown that the critical angle of the prism can be derived from the dispersion formula without involving a cubical equation as stated by Erfle. The paper is mathematical throughout. H. H. Ho.

152. *Accuracy in Colour-Matching of Incandescent Light Sources.* **W. E. Forsythe.** (Optical Soc. America, J. 6. pp. 476–482, Aug., 1922.)—Two tests have been made of accuracy that can be obtained in colour-matching. The first test was for different observers. It was found that experienced observers agreed in their values for colour match to about 3° K. for a colour temperature of about 2400° K. The second test was for colour-matching for different illuminations on the photometer screen. No very great difference was obtained in the accuracy for a range in illumination from 1·8 foot-candles to 45 foot-candles. AUTHOR.

153. *The Effect of Certain Dissolved Substances on the Infra-Red Absorption of Water.* **J. R. Collins.** (Phys. Rev. 20. pp. 486–498, Nov., 1922.)—Infra-red absorption spectra of aqueous solutions of sixteen inorganic compounds from 0·8 to 2·3 μ, have been determined to see how the dissolved substances affect the absorption of the water. Care was taken to eliminate stray light by using two constant deviation glass spectroscopes in series. Readings were taken alternately with a cell containing a solution and with one containing water. Curves were thus obtained for the alkali hydroxides, five chlorides (Al, Ca, Mg, Na, Sr), five nitrates (Ag, Al, Mg, NH_4, Zn) and three sulphates (Ag, Na, Zn). All solutes decreased the absorption in the water band at 1·44 μ and probably also in the band at 2 μ, whereas all excepting $Al_2(SO_4)_3$, $ZnSO_4$, and the hydroxides increased the

absorption in the bands at 0·97 and 1·2 μ. These results do not agree with the solvate theory which ascribes the effect to the formation of hydrates, since some non-hydrating compounds decreased the absorption at 1·44 μ.

Absorption of water, from 0·8 to 2·3 μ, was measured by using cells of different known thicknesses. The wave-lengths of maximum absorption were found to be 0·97, 1·20, 1·44, and 2·00 μ, and the corresponding coefficients came out at the values 0·448, 1·220, 29·4, and 103, respectively. AUTHOR.

154. *Relation between the Chemical and Photo-Luminescence of Unsaturated Silicon Compounds.* **H. Kautsky** and **H. Zocher.** (Zeits. f. Physik, 9. 5. pp. 267–284, 1922.)—Unsaturated silicon compounds have been shown to exhibit strong chemical luminescence on oxidation; these phenomena are now more rigidly described. The raw material employed is calcium silicide, $CaSi_2$, which on treatment with hydrochloric acid gives products showing at least three stages of oxidation before the final state of silicic acid is reached, viz.: (1) Colourless oxydisilin, Si_2H_2O; (2) coloured silical compounds $(Si_2OH)R$, where R is a negative atom or radicle; (3) colourless leukon of unknown composition. Only the first two stages have been investigated, and more especially oxidation with ethyl iodide, chloroform or carbon tetrachloride in the presence of water by the agency of light. The red silical hydroxide was employed in these investigations. The colour of the emitted light changes with increasing concentration of silical hydroxide from green through yellow to red, similar to the changing shade of the reacting substance. The intensity of the luminescence is greatest for the yellow luminous preparations at the smaller concentrations of silical hydroxide. At lower temperatures, and for equal amounts of oxidising substance, a greater amount of light is radiated. The spectrum of the luminescence is found to be a broad band from red to green, the short-wave rays not being emitted. The photochemical oxidation of the oxydisilin (Si_2HOH) to silical hydroxide with ethyl iodide and water is effected by short-wave light, and the silical hydroxide formed reacts as an auto-catalyst. The oxidation of the red silical hydroxide to colourless leukon is likewise accelerated by short-wave light, and this bleaching effect occurs *in vacuo*, with a dry preparation. The photochemical oxidation of the silical hydroxide caused by short-wave light is accompanied by an emission of long-wave light, i.e. by photo-luminescence, whose colour is the same as that of the chemical luminescence, and is subject to light variations with respect to colour and intensity with changing concentration of silical hydroxide. At the temperature of liquid air the chemical reaction is reduced to a minimum, while the photo-luminescence on the other hand is extraordinarily strengthened and displaced simultaneously with the absorption to shorter wave-lengths. The substance when illuminated in liquid air exhibits phosphorescence and thermo-luminescence of colour like the chemical luminescence. Silical hydroxide exhibits a strong kathode luminescence whose colour is the same as the chemical and shows similar variations. The photo, as also the chemical luminescence of single leaf-like particles of silical hydroxide, is polarised, the direction of vibration in both cases lying in the plane of the lamina. From different results it appears probable that light emission transpires in all cases by means of non-reacting silical hydroxide molecules. It appears probable from these experiments that an energy

transference from molecule to molecule plays a part not only in chemical and photo-luminescence, but also during the auto-catalytic formation of silical hydroxide from oxydisilin in presence of light, as also for other auto-catalytic reactions (also for such without participation of light).

H. H. Ho.

155. *The Exciting Power for Fluorescence of the Different Parts of the Ultra-Violet Spectrum.* **L. J. Boardman.** (Phys. Rev. 20. pp. 552 572, Dec., 1922.)—Light from a source giving a continuous spectrum was dispersed by means of a quartz spectrograph and allowed to fall on the substance to be studied which was spread on a flat surface. Then the parts of the spectrum which excited fluorescence were observed or photographed by means of the fluorescent light. A preliminary study of seventy substances showed that all the oxides (20) and simple chlorides (8) tested were not excited, a few substances (7) including zinc silicate, zinc sulphate, and cadmium phosphate fluoresced faintly, a few responded well (anthracene, eosin, fluorescein, phenol-phthalein, calcium tungstate, and phosphorescent willemite), while the uranyl compounds (20) fluoresced strongly. For the last group the effective spectrum extended from $0{\cdot}55$ to $0{\cdot}35\,\mu$ only, while for the others it extended continuously to $0{\cdot}2\,\mu$ except in the case of four substances for which light from $0{\cdot}35$ to $0{\cdot}325$ was ineffective. *The excitation band spectrum for twelve uranyl compounds* was determined by measuring the density of the plates as a function of the wave-length by means of a sensitive photoelectric spectrophotometer. Some curves are reproduced and the wave-numbers corresponding to from 35 to 105 maxima for each compound are given. Comparison with absorption spectra shows close agreement, an absorption band corresponding to an excitation band in every case. This relation had previously been found by Howe to hold for phosphorescent sulphides.

Absorption Spectrum of Twelve Uranyl Compounds, from $0{\cdot}55$ *to* $0{\cdot}32\,\mu$. —Because of the correspondence noted above the excitation bands may be taken to be absorption bands and thus the known absorption spectrum be considerably extended toward both the red and ultra-violet. Comparison of these bands with the fluorescence spectrum indicates clearly many new reversing regions where the fluorescent light obscures the absorbing effect. These are listed. AUTHOR.

156. *The Absorption of Light by Sulphur at Various Temperatures.* **M. Fukuda.** (Kyoto Coll. Sci., Mem. 4. pp. 351–354, March, 1921.)—An experiment is described to determine the shifting of the absorption band of sulphur with variation of temperature. A thin layer of sulphur having been prepared between glass plates and connected with a thermo-couple consisting of platinum and tungsten, the absorption spectra of the sulphur at various temperatures were examined with a spectrograph having a replica grating. The source of light was a carbon arc fed with a salt of calcium, and wave-lengths of an edge of the absorption bands at various temperatures were determined from the reference lines of calcium. These wave-lengths did not differ by more than $3\,\mu\mu$. They are shown in a table, from which it appears that the less refrangible edge of the absorption band of sulphur proceeds towards the red as the temperature rises, a rise of 10° C. producing a shift of about $2\,\mu\mu$. A study of the absorption of light by sulphur in a plastic state showed that this absorption depends not only on its present temperature, but also on the initial tempera-

ture to which the sulphur was heated : the higher the initial temperature the longer the wave-length of the edge of the absorption band. Sulphur has two modifications, S_6 and S_{18}, and if gradually cooled from 300° C. to 100° C., for example, S_{18} would be completely transformed into S_6, but if rapidly cooled this is not the case, because its absorption spectrum corresponds to that of a temperature of about 180° C. The plastic sulphur will thus consist of a complex mixture of S_6 and S_{18}. E. F.

157. *Ultra-Violet Absorption of Diphenols.* **F. W. Klingstedt.** (Comptes Rendus, 175. pp. 365–367, Aug. 21, 1922.)—Meta- and ortho-diphenols have spectra very like that of phenol (bands A, B, C), while para-diphenol presents, instead, eight bands almost equidistant. That is, in hexanic solution ; in alcoholic solution these bands all fuse together. A. D.

158. *Relative Intensities of Stark Effect Components in the Helium Spectrum.* **J. S. Foster.** (Phys. Rev. 20. pp. 214–220, Sept., 1922.)—*Modified Lo Surdo Tube for Observing the Stark Effect.*—By placing the tube with its axis perpendicular to the slit and using the cross-section of the kathode efflux where the field is a maximum, separate and parallel components were obtained. Pitting of the aluminium kathode, however, causes a gradual shifting of the field and consequent blurring of the components with exposures of several hours, and this limits the usefulness of the method at present.

Relative Intensities of the Stark Effect Components of the Helium Lines λλ4922, 4472, and 4388 Å. *in a Field of* 15,000 *volts/cm.*—Spectrograms were taken of the *p* and *s* components in turn through a neutral wedge, using a five-prism spectrograph ; then energy distribution curves were calculated from the contour of the images and the corresponding wedge densities, and the relative intensities were obtained by integration. The results for the main *p* components follow in order of increasing wave-length : for the line 4388, 8·2 (isolated), 4·1, 19·2, 28·0 ; for 4472, 168, 694 ; for 4922, 9·7, 31·6. Corresponding results for the *s* components are : for 4388, 1·0 (isolated), 3·0, 11·3, 9·5 ; for 4472, 76, 464 ; for 4922, 6·2, 21·4. AUTHOR.

159. *Revision of the Series in the Spectrum of Strontium.* **F. A. Saunders.** (Astrophys. J. 56. pp. 73–83, Sept., 1922.)—*Series of Triplets and Singlets.*—These series belong to the neutral atom of Sr. Their remarkable similarity to the corresponding series of Ca, which have previously been critically studied, was of great assistance in working out the structure. The present study is based on measurements of spectrograms, from ultra-violet to infra-red, taken by Randall King, and the author, of light from a great variety of sources, including sparks, arc in air and *in vacuo*, tube-resistance furnace, and red-hot quartz discharge tube containing very pure Sr vapour. Revised wave-lengths are given for most of the 180 lines from 0·22 to 3·06 μ, including some seventy new lines. The limits of all the series have been more accurately found, and the various " terms " have been calculated. Details are given, with tables, of four type series of triplets and four of singlets, four combination series in the triplet system, three in the singlet system, and five inter-system combination series. Of the twenty series here mentioned, some are very faint and are represented by one term only, and about half are

believed to be new. Evidence is also presented of the existence of *new types of single series* corresponding to formulæ (1P) — (mX), ($1p$) — (mX), (1P) — (mY), etc. The terms are all large, so that the series cannot be of the sort suggested by Sommerfeld.

New Type of Series of Singlets in the Spectrum of Calcium.—Three singlet lines are found to correspond accurately to (1P) — (mX), ($1p_1$) — (mX) and ($1p_2$) — (mX) where (mX) is 8584·8. This points to the existence of series similar to those last mentioned for Sr. AUTHOR.

160. *Spectra of Hydrogen, Nitrogen, and Oxygen in the Extreme Ultra-Violet.* **J. J. Hopfield.** (Phys. Rev. 20. pp. 573–588, Dec., 1922.)—*Spectroscopy of Extreme Ultra-Violet.*—A method which has been developed of coating films with an emulsion suitable for work in this region is described in detail, and also an oil-cooled discharge tube of the internal capillary type which will stand an input of 2·25 kw. and thus reduce the time of exposure and consequent fogging of the films from 10 to 100 fold. Transparency of oxygen, nitrogen, and air between 500 and 1800 Å. was investigated. In a vacuum spectrograph with a grating of 50 cm. radius these gases were found to transmit light of from 1100 to 1225 Å. even when at a pressure of 3 cm. At about 1 mm. spectrum lines were photographed from 800 to 1800 Å. and with oxygen at 0·001 mm., the spectrum was photographed to 430 Å. These gases, then, are not as opaque to light in this region of the spectrum as has been generally supposed.

Spectrum of Discharge through Hydrogen, 1220 to 885 Å.—The ultra-violet limit is the same for both continuous and disruptive discharges. The resonance line was found superimposed in the fourth order on the H_β line; hence its wave-length is 1215·68 ± 0·03 Å. This coincidence confirms the Bohr formula for this line, which is the first of the Lyman series.

Spectrum of Discharge through Nitrogen, 1750 to 835 Å.—The continuous discharge gives chiefly the band spectrum of nitrogen, which is extended to 1026 Å., the wave-lengths of 10 bands below 1385 Å. being given. The wave-lengths of 50 new lines obtained with the disruptive discharge are also given and four spectrograms are reproduced.

Spectrum of Discharge through Oxygen, 1863 *to* 507 Å.—Wave-lengths of about 100 new lines obtained with a disruptive discharge are given and six spectrograms are reproduced. When mercury vapour was present about 15 additional lines extending to 433 Å. were obtained. AUTHOR.

161. *Quantum Theory of Spectrum Lines of Neutral Helium.* **L. Silberstein.** (Eastman Kodak Co., Research Lab. No. 156. Astrophys. J. 56. pp. 119–131, Sept., 1922.)—No attempt has hitherto been made to account for any of these lines because, since the neutral atom has two electrons besides the nucleus, the theoretical explanation is generally supposed to depend on the solution of the problem of three bodies. But while we do not possess a general solution of this problem, particular solutions are known and it is of interest to see what results they give. For the case of permanent collinearity of the three bodies, we get a spectral formula of the Balmer type, $\nu = (40/N8)(1/n^2 - 1/m^2)$, but this represents none of the observed lines. If, however, we assume that the mutual perturbation of the electrons is negligible, the formula comes out $\nu = 4N \times [1/n_1^2 - 1/m_1^2 + 1/n_2^2 - 1/m_2^2]$; and if the proper integral values are taken, up to 9 for the n's and up to 32 for the m's, this formula gives 84 out of

the 111 observed lines, in general within a fraction of an Ångstrom. Although the resulting classification does not correspond to the usual series arrangement, the success of the formula suggests that the *force between intraatomic electrons* may be much less than that given by the Coulomb law. AUTHOR.

162. *New Evidence Regarding the Interpretation of Critical Potentials in Hydrogen.* **P. S. Olmstead.** (Phys. Rev. 20. pp. 613–630, Dec., 1922.) —(1) *Experimental Separation of Effects due to Atomic and Molecular Hydrogen.*—In an ionisation tube of the Lenard type, a close grid of tungsten wires was introduced between the filament and the gauze in front of the plate. When this grid was heated electrically to incandescence the proportion of atoms was greatly increased by dissociation of the molecules. (2) *Effects due to radiation were distinguished from effects of ionisation* by comparing the electron currents to a disc electrode with those to a wire which, because of its small area, was relatively insensitive to effects of radiation. (3) *Six critical potentials between* 10 *and* 16 *volts* were observed and measured with reference to the strongest break, assumed to occur at 16·0 volts. Each break point was located at the intersection of two tangents; hence the relative values are probably accurate to 2 or 3 per cent. Purified electrolytic hydrogen was used. (4) *Experimental interpretation* of the breaks, which agrees in general with the previous theoretical interpretation based on quantum theory, is as follows: radiation from the atom at 10·1 and at 12·2 volts, corresponding to the first two terms of the Lyman series; ionisation of the molecule at 11·5 volts and of the atom at 13·6 volts; dissociation of the molecule and radiation at 12·9 volts; finally, dissociation of the molecule and ionisation of one of its parts at 16·0 volts. The energy required for dissociation of the molecule is therefore equivalent to about 2·8 volts. AUTHOR.

163. *Low-Voltage Arcs in Diatomic Gases.*—I. *Hydrogen, Nitrogen, and Iodine.* **O. S. Duffendack.** (Phys. Rev. 20. pp. 665–687, Dec., 1922.) —After a general review of the previous experimental results and theoretical suggestions, current-voltage curves obtained with a simple two-electrode tube are described. Precautions were taken to insure pure gases. The breaking potential was always the ionising potential of the gas, 16·3, 16·2 and 14·6 volts, respectively, for the three gases. The striking potential was greater than the breaking one by an amount which increased with the pressure and with increasing kathode filament temperature. In dissociated hydrogen, maintained at a high temperature within a thin tungsten cylinder heated electrically, an arc was readily maintained at the ionising potential of the atom, 13·7 volts, and under very favourable conditions, at the radiating potential, 10·0 volts. In dissociated iodine vapour, the arc was maintained at 12·1 volts and under certain conditions at the ionising potential, 10·2 volts. Nitrogen was not appreciably dissociated in the furnace. The critical potentials given above agree with the best previous results within ± 0·2 volt as a rule. Those associated with the atom are experimentally distinguished from those associated with the molecule.

Electric Furnace Spectra of Hydrogen, Nitrogen, and Iodine to 2500° *C.* —In hydrogen, the series lines flashed in when the arc was struck, even as low as 10·6 volts, but the bands did not appear. Evidently the series lines are due to the atom and the bands to the molecule. In nitrogen,

a brilliant "flare" was produced at potentials which decreased from 70 to 40 volts as the temperature was increased. This "flare" shows both the positive and negative bands along with the spectrum of tungsten; it is probably due to the formation of "active" nitrogen. At 70 volts the first lines, 5006 and 5003 Å., appeared, and at 90 volts only two more, 5680 and 5667 Å. Reasons are given for assigning the positive bands to the neutral molecule, the negative bands to the ionised molecule, and the lines to the atom. In iodine, the arc lines, particularly 4860 Å., flashed in when the arc struck, the enhanced lines coming in at higher voltages. No band spectrum appeared. New negative bands of nitrogen were found at 5075, 5018, and 4961 Å. AUTHOR.

164. *Mica X-Ray Spectrometer.* **U. Yoshida** (Kyoto Coll. Sci., Mem. 4. pp. 343-347, March, 1921.)—Broglie and Lindemann and simultaneously Rohmann first devised a bent mica X-ray spectrometer and calculated the grating constant d as about 10×10^{-8} cm. Gorton obtained a different result. Previous measurements with this type of spectrometer have not been so accurate as with other types of X-ray spectrometers. The author has used Gorton's instrument to determine its accuracy. The instrument consists of a lead box with a slit of 0·3 mm. and a wooden cylinder on which is a sheet of mica 0·07 mm. thick, giving a total radius of 36·46 mm. The mica cylinder is in such a position that the perpendicular from the slit to the plane of a photographic plate is exactly a tangent to the mica cylinder. A lead screen is interposed to protect one-half of the photographic plate to all except reflected rays.

The author gives the mathematical relation between the deviation of the ray and the glancing angle, with numerical data for d and wave-lengths. The value of d calculated from his observations is 9·911 Å.U., which is 1 % smaller than that given by Broglie and Lindemann. The wave-lengths of lines observed (for tungsten) agree with values given by Siegbahn and Dershem. B. J. L.

165. *The Tungsten X-Ray Spectrum with a Mica Spectrometer.* **U. Yoshida** and **S. Tanaka.** (Kyoto Coll. Sci., Mem. 5. No. 3. pp. 173–178, Dec., 1921.)—The X-ray spectrum of the L series of tungsten has been thoroughly investigated by Dershem, Overn, and, Siegbahn, and, whilst there is fair agreement, ambiguities occur in regard to faint lines. The authors used a spectrometer essentially the same as that described in the preceding abstract. The time of exposure with a Coolidge tube and a current of 4–7 milliamperes was 30–60 hours. All the prominent lines of the L series were visible up to the order of the fifth and more and many weak lines showed themselves. The wave-lengths of weak lines in the region of wave-lengths below the fifth order were determined by interpolation with Siegbahn's values for α_2, α_1, β_4, β_1, β_3, β_2, γ_1, and the grating constant so calculated was 9·858 Å.U. Wave-lengths of weak lines above the fifth order were calculated from this grating constant. The wave-lengths in most cases are in agreement with those given by other investigators, but the line η was found to be smaller. A line observed by Dershem and Overn is confirmed.

From their results the authors conclude that the mica X-ray spectrometer allows lines of the 7th and even 10th order of the L series of tungsten to be obtained. Eleven unknown lines were detected for

which the wave-lengths are given, but the authors observe that these lines may be due to reflection from the mica in some unknown manner.
B. J. L.

166. *An Experimental Study of the Scattering of Approximately Homogeneous X-Rays by Powdered Crystalline Carbon, Metallic Lithium, and Liquid Benzene, Mesitylene, and Octane.* **C. W. Hewlett.** (Phys. Rev. 20. pp. 688–708, Dec., 1922.)—The intensity of the radiation scattered by the substance contained in a small capsule placed at the centre of the spectrometer was measured by the ionisation method for angles from 2° to 165°. While a ZrO_2 screen was used to isolate the K_a^2 line of Mo (0·712 Å.), some radiation of $\lambda 0{\cdot}445$ Å. was apparently also present. For diamond, graphite, and lithium, the maxima agree in position and relative intensity with those found by A. W. Hull by the photographic method. The curves for the liquids, however, are remarkable in that each shows one maximum; 8·5° for benzene, 6·5° for mesitylene, and 8·1° for octane, with indications of others unresolved, suggesting that the liquids have a crystal structure. For very small angles the scattering is zero for the solids, and approaches zero for the liquids. Mass-scattering coefficients were obtained by integrating the area under the curves, or by experimentally integrating the ionisation for all angles of scattering. The coefficients for carbon (diamond and graphite), 0·200, and for lithium, 0·168, agree with Thomson's theoretical values. For benzene, mesitylene, and octane, however, the values 0·238, 0·244, and 0·262 respectively are about ten per cent. larger than those predicted by theory, and give too large specific values for carbon and hydrogen, 0·22 and 0·46 instead of 0·20 and 0·40 respectively. The results are probably accurate to three per cent. True wave-absorption coefficients, obtained from the total absorption, the scattering and the density, are found for the solids to be in accord with the theoretical expression $KN^3\lambda^3$, the mean value of K being $4{\cdot}38 \times 10^{-3}$.

Evidence of crystal structure of liquids seems to have been found in the scattering curves for benzene, mesitylene, and octane, as suggested above, and the spacings of the planes of atoms responsible for the principal maximum are benzene 4·8 Å., mesitylene 6·3 Å., and octane 5·0 Å.
Author.

167. *Absorption Coefficients for Homogeneous X-Rays.* **E. G. Taylor.** (Phys. Rev. 20. pp. 709–714, Dec., 1922.)—By means of a spectrometer with narrow lead slits and a calcite crystal, the K_a radiation from the Mo target of a Coolidge tube was reflected into an ionisation chamber, and the effect of interposing a cell containing a known thickness of liquid before the first slit, was measured. Thus absorption coefficients for wave-length 0·715 Å. were determined for carefully purified samples of pinene ($C_{10}H_{16}$), limonene ($C_{10}H_{16}$), benzene (C_6H_6), toluol (C_7H_8), isopropyl alcohol (C_3H_8O), methyl proprionate ($C_4H_8O_2$), ethyl acetate ($C_4H_8O_2$), acetone (C_3H_6O), ethyl formate ($C_3H_6O_2$), and trimethylene glycol ($C_3H_8O_2$).

Atomic absorption coefficients for C, H, and O for X-rays of wave-length 0·715 Å. *were computed* from the above data, assuming absorption to be an additive atomic property, and came out from $11{\cdot}00$ to $11{\cdot}55 \times 10^{-24}$ for C, $0{\cdot}45$ to $0{\cdot}50 \times 10^{-24}$ for H, and $29{\cdot}9$ to $31{\cdot}0 \times 10^{-24}$ for O. Using the mean values, the computed coefficients are within

$\frac{1}{3}$ per cent. of the observations, on the average. But the fact that the computed values for acetone and water are 1 per cent. too low suggests that the assumption that absorption is an atomic property may not be accurately true. AUTHOR.

168. *The Effect of Temperature on the Scattering of X-Rays by Crystals (Rock Salt and Calcite).* **G. E. M. Jauncey.** (Phys. Rev. 20. pp. 421–423, Nov., 1922.)—Using X-rays from the W target of a Coolidge tube operated at 95 kv., the ratio of the radiation scattered from a crystal at 295° C. to that scattered at the same angle from the crystal at 17° C. was found to be: 1·33 and 1·18 ± 0·10 for rock salt and angles of 15° and 30° respectively, and 0·99 and 1·03 ± 0·04 for calcite and angles of 30° and 73° respectively. Thus there is a marked effect for rock salt, but apparently none for calcite, which seems to scatter X-rays like an amorphous substance. Comparison with the Debye theory shows that even for rock salt the effect is considerably smaller than that theoretically predicted, whether zero-point energy is assumed or not, while for calcite the disagreement is marked. AUTHOR.

169. *The Scattering of X-Rays by Rock Salt, Calcite, Aluminium, and Glass.* **G. E. M. Jauncey.** (Phys. Rev. 20. pp. 405–420, Nov., 1922.) —Both homogeneous rays (K_α of Mo obtained by preliminary reflection from a rock-salt crystal) and heterogeneous rays direct from a Mo or W target (70 to 110 kv.) were used, and scattering curves were obtained by measuring the ionisation for various angles of scattering. On account of the small intensity of the scattered radiation, incident beams of 15′ to 3° width and a scattered beam of 6° width were required even with a sensitive Compton electrometer. For angles from 50° to 150° the curves obtained for the crystals are of the same shape as those for Al and glass, each curve showing a minimum at about 100°; but for angles below 50° the crystal curves fall below the others and each shows a maximum at a larger angle, between 15° and 30°, depending on the wave-length. In addition to the general scattering at all angles, there appear, for the crystalline substances, maxima corresponding to the Laue spots. When correction for the absorption of the crystal is made, for which a formula is given, the scattering in a particular direction is found not to depend on the orientation of the crystal. This indicates that the atoms are isotropic. As was to be expected, the scattered radiation was softer than the primary. For the width of X-ray beams used the total energy scattered in all directions was an appreciable fraction (0·70 for homogeneous Mo K_α^2 rays on calcite) of the energy reflected in a first order spectrum line. Comparison with the Debye theory shows fair agreement only in the case of rock salt for angles greater than 60°. For calcite there is no agreement, and the prediction that the scattering by amorphous substances should be quite different from that by crystals is not verified. Applying the Thomson formula, however, the number of electrons per molecule for each crystal has been calculated from the relative amount of energy scattered at 90° and comes out of the right order of magnitude. AUTHOR.

RADIO-ACTIVITY.

170. *The Effect of the Magnetic Field on the Absorption of X-Rays.* **J. A. Becker.** (Phys. Rev. 20. pp. 134–147, Aug., 1922.)—Effect of a magnetic field on the absorption of X-rays, if it can be measured, would have an important bearing on the theory of atomic structure. Since the effect is very small, a differential method was adopted and by eliminating various spurious effects the apparatus was made sensitive enough to detect a change of 1 part in 10,000. Observations were made with a peak voltage of 80 kv. across the Coolidge tube (mean wave-length about 0·3 Å.) and with a magnetic field H of about 18,000 gauss. For H perpendicular to the rays, aluminium, carbon, copper, iron, nickel, platinum, zinc, and silver showed changes in absorption coefficients of $+ 8 \pm 6$, $- 5{\cdot}6 \pm 2$, $+ 0{\cdot}8 \pm 0{\cdot}4$, $- 10 \pm 2$, $+ 1{\cdot}6 \pm 0{\cdot}5$, $+ 1{\cdot}7 \pm 0{\cdot}4$, $- 1{\cdot}2 \pm 0{\cdot}4$, and $+ 1{\cdot}6 \pm 0{\cdot}8$ parts in 10,000 respectively, while with H parallel to the rays the corresponding changes were $+ 2{\cdot}7 \pm 1$, $+ 3 \pm 1$, $+ 1{\cdot}4 \pm 1$, $- 0{\cdot}5 \pm 2$, $+ 0{\cdot}7 \pm 2$, $+ 1{\cdot}1 \pm 1$, and $+ 1{\cdot}3 \pm 1 \times 10^{-4}$, silver not being tried. These results are in accord with the hypothesis that the magnetic properties are largely determined by the outer shell or valency electrons, since at the wave-lengths used by far the greater part of the absorption is due to the inner electrons. Wood was also tested with softer rays having a mean wave-length of about 1·2 Å., and showed a change of $+ 80 \pm 20 \times 10^{-4}$ as compared with 3×10^{-4} for carbon for wave-length 0·3 Å. Following the suggestion of this result it is proposed to do further work with light elements and softer X-rays.

Differential Method of Measuring Small Changes of Intensity of an X-Ray Beam.—The apparatus, which includes two similar ionisation chambers connected so that the ionisation currents nearly neutralise each other, is described in detail together with the precautions necessary to eliminate various sources of error and to attain the sensitivity mentioned above.

Bumstead Electroscope.—A simple type is described. Care should be taken to eliminate convection currents within the instrument. Author.

171. *An Instrument for the Gamma-Ray Measurement of the Radium Content of Weakly Active Materials.* **N. E. Dorsey.** (Optical Soc. America, J. 6. pp. 633–638, Aug., 1922.)—The author describes a modification of W. Bothe's method [see Abstract 1062 (1915)] of measuring the radium content of feebly radio-active substances. It consists of a triple cylinder ionisation chamber attached to an electroscope, the active material being introduced into the inner cylinder. It has distinct advantages over Bothe's arrangement in the case of manipulation. The sensitivity of the instrument used by the author was about 2·8 divisions per second per milligramme of radium. Specimens of radium concentrates containing from 7 to 60 microgrammes and small preparations containing as much as 300 microgrammes of radium were satisfactorily measured to a precision of at least 1 %. Though the instrument is well suited to the determination of the radium content of concentrates, it is not suitable for work with low-grade ores. For such work a more sensitive instrument or one utilising a larger amount of active material would be required.

E. A. O.

HEAT.

172. *Adjustable Thermostat.* **S. J. Lewis** and **F. M. Wood.** (Faraday Soc., Trans. 17. pp. 696–700; Disc., 701–702, May, 1922.)—A large thermostat, very readily adjustable for use at any temperature between 0° and 100° C., and reliably maintained constant to $\frac{1}{100}$th of a degree or less. A. D.

173. *Heat Flow in a Finite Cylinder having Variable Surface Temperature.* **G. E. Thompson.** (Phys. Rev. 20. pp. 601–606, Dec., 1922.)—Equations of heat flow into finite circular cylinders when the surface temperature is changed either suddenly or at a uniform rate, are derived. In the first case the surface temperature of a cylinder whose temperature is initially uniform throughout is suddenly changed from 0 to V_0, kept there for a certain time and then suddenly changed to V_2 and kept there indefinitely. In the second case the surface temperature is changed to V_0, then is increased at a uniform rate from V_0 to V_2 and then is kept constant indefinitely. These two cases correspond roughly to the *changes occurring in two canning processes* and the theoretical curve for the second case is found to agree roughly with an experimental curve obtained with a pint Mason jar filled with spinach by the "cold-pack" method. Author.

174. *Quenching: a Mathematical Study of Various Hypotheses on Rapid Cooling.* **K. Heindlhofer.** (Phys. Rev. 20. pp. 221–242, Sept., 1922.)—(1) Assuming no thermal resistance at the surface, theoretical cooling curves for a steel ball and a steel plate are computed. (2) Assuming constant thermal resistance, the general equation is derived for the case of a cylinder of finite length. (3) Assuming a vapour layer which conducts the heat to a liquid layer at rest, the general solutions for the temperatures at the surface of a large body and of a plate are obtained. (4) Assuming that the heat after passing through the vapour layer is carried away by convection at a uniform rate, the equation and curves are obtained for the case of a plate. By comparing various experimental cooling curves with the theoretical curves obtained above, it is evident that after the first stage of quenching none of the assumed conditions correspond to the facts. It is found that the rate of transfer of heat through the surface is not constant, but is an exponential function of the temperature of the surface. Smaller cylinders seem to have less specific heat flow. The discrepancy with theory is doubtless due to the neglect of the bubbling which begins almost immediately. Reheating of the surface of a body immediately after quenching, due to sudden formation of a steam jacket, does not occur. Reheating as evidenced by structural investigation may occur in a later phase of quenching. Author.

175. *Vapour Pressures of Ternary Mixtures.* **A. W. Porter.** (Faraday Soc., Trans. 18. pp. 19–21, Oct., 1922.)—In a previous paper [see Abs. 1288 (1921)] the author has shown that, except in those cases in which chemical action may be presumed, the vapour pressures of binary mixtures can be represented very satisfactorily by formulæ of the type:

$$\pi_a = \pi_a \mu_a \exp.\ [\beta \mu_b^2] \text{ and } \pi_b = \pi_b \mu_b \exp.\ [\beta \mu_a^2].$$

and further that these formulæ can be derived from a potential function P where

$$P = \mu_a \log \mu_a + \mu_b \log \mu_b + \beta \mu_a \mu_b$$

by differentiating partially with respect to n_a and n_b (the numbers of molecules) in turn, while μ_a, μ_b are the molar fractions $n_a/n_a + n_b$ and $n_b/n_a + n_b$, and π_a, π_b are the vapour pressures of the separated constituents. This enabled an extension to be made to ternary (and higher order) mixtures. Experimental data obtained by Rosanoff, Schulze, and Dunphy are now utilised for illustrating these formulæ. Unfortunately, the actual vapour pressures in the gaseous phase were not determined by the above authors, but only the percentage concentrations corresponding to given concentrations in the liquid phase. The comparison between formulæ and experiment has been carried out at 83° C. and 99° C., two tables of results being given. The liquids used were toluene, carbon tetrachloride, and ethylene bromide. H. H. Ho.

176. *Measurement of Mercury Vapour Pressure by Means of the Knudsen Pressure Gauge.* **C. F. Hill.** (Phys. Rev. 20. pp. 259–266, Sept., 1922.)—The disagreement among the results obtained by previous observers for this range of temperature suggested the need for a direct determination of the vapour pressures with a Knudsen gauge. Impurities were eliminated by numerous distillations in a system cut off from the pump by a liquid air trap, and the slight amount of residual gas was corrected for. The readings obtained at 19 temperatures lie near a smooth curve which, it is believed, gives the vapour pressures to within 3 per cent. The values for 0, 10, 20, and 30° C. are, respectively, 0·000350, 0·000775, 0·00182, and 0·00407 mm. of Hg, considerably higher than those obtained by Knudsen in 1909, but agreeing fairly well with Morley's results up to 15°, and at higher temperatures with values extrapolated from the results of Ramsay and Young. Author.

177. *Solid Bodies at Low Temperatures.* **W. Meissner.** (Zeits. Vereines deutsch. Ing. 66. pp. 845–847, Sept. 9, and pp. 876–878, Sept. 16, 1922.)—A discussion, from the point of view of the quantum theory and Nernst's law, of specific heat, expansion by heat, electrical conductivity, thermal conductivity, thermo-electricity, and magnetisation at low temperatures. A. D.

178. *A Modification of van der Waals' Equation.* **W. P. Boynton** and **A. Bramley.** (Phys. Rev. 20. pp. 46–50, July, 1922.)—The proposed equation is $(p + a/v^2)(v - b) = RT/(1 + \psi^2/T^2)$, where ψ is a characteristic temperature. It represents the behaviour of CO_2 and other substances more closely and gives better values of the ratio $T_c/p_c v_c$. While the corrective factor is purely arbitrary, it resembles those of certain theoretical equations having a rational basis and also lends itself to mathematical treatment. It is shown that not only the energy but also the specific heat and entropy derived from this equation approach zero values at absolute zero in agreement with conclusions from the researches of Nernst. Theoretical formulæ for specific heat (c_v), internal energy and entropy as functions of T and v, are derived from thermodynamic laws and the equation of state given above. Authors.

physics-abstracts_1923

SOUND.

179. *The Vibrating String as a Measure of Extension.* **O. Schaefer.** (Zeits. techn. Physik, 3. 9. pp. 305–310, 1922.)—The fundamental idea of this investigation is that to a body of known elasticity, whose constants have been determined for a given load, a steel wire is attached in such a manner and under such a tension that it gives a tone of average pitch when the body is unloaded. The change in tone is then measured for a given load and from it the extension or contraction of the wire calculated; this is related to the elastic displacement of the stretched portion and therefore permits conclusions with respect to the tensions in bodies investigated. The technical value of such a method for laboratories and works is emphasised. The measurement of pitch is made by comparison with a second wire, and full experimental details are included in the paper; together with precautions and corrections. Experiments are described finally for estimating the degree of accuracy of the method, tables of results and errors being introduced. H. H. Ho.

180. *The Action of the Bow in Stringed Instruments.* **K. C. Kar.** (Phys. Rev. 20. pp. 148–153, Sept., 1922.)—*Motion of Points of a String near the Bowing Region.*—Shadows of a small section of the horizontal string and of pins stuck in the bow were thrown on a vertical slit, behind which a piece of photographic paper was moved. The resulting prints each show a saw-tooth line due to the string, crossed by inclined straight lines due to the pins. Experiments were made with the bow one-seventh, one-tenth, and one-fourteenth of the length of the string from one end. In every case the speed of the points of the string is proportional to the distance from the near end. The point with a speed equal to that of the bow is called the zero point. With strong slow bowing the zero point is at the outer edge of the bow, but with lighter or faster bowing the zero point may be 2 cm. or more nearer the middle of the string. While the "wolf note" is sounding the zero point oscillates periodically with the beating; it may be stopped by increasing the pressure. The amplitude at the outer edge of the bow is proportional to the speed of the string at that point and hence will change as the zero point is shifted by variations of pressure, even when the bowing speed is constant. Author.

181. *Overblown Pipes.* I. **S. Bhargava** and **R. N. Ghosh.** (Phys. Rev. 20. pp. 452–455, Nov., 1922.)—It is well known that as the blowing pressure is increased, first the fundamental is excited, then the octave appears, then after an interval of beating the octave alone is heard. With the pipe tested (fundamental pitch 490), as the lip distance was increased from 8 to 12 mm., the minimum pressures for the fundamental and octave, respectively, increased from 0·4 to 0·9 cm. and from 2 to 25 cm. of Hg. Change of pitch of a pipe with blowing pressure is well known. For a particular pipe, studied with the help of phonodeik records, the fundamental pitch increased from 490 to 505 as the pressure was increased from 6 to 32 cm. of water. For 50 cm. of water the pitch (octave) was 1052. Authors.

182. *Reports and Noises, and the Intervals of their Components.* **A. Stromann.** (Phys. Zeits. 23. pp. 313–318, Aug. 15, 1922.)—The report of an explosion consists of few vibrations of the air, of which the first is paramount. Other reports consist of the vibrations proper to bodies, and have the genuine report character only for a very short duration, and may be classed with noises. Noises may be divided into two subclasses, those of the type just mentioned, and others arising from high-frequency puffs of air. The paper describes a number of experiments carried out with special sirens, the discs being bored with few holes, so as to give special combinations. These are described by aid of many diagrams and various tabulations. E. H. B.

183. *Cases of Nerve-Deafness and Theories of Audition.* **J. P. Minton.** (Nat. Acad. Sci., Proc. 8. pp. 274–280, Sept., 1922.)—The present paper deals with certain cases of nerve-deafness and their supposed bearing on the mechanical resonance theories of tone perception [see Abs. 1348 (1922)]. It is generally accepted among medical men that the purpose of an end organ is to lower the threshold of perception of certain sensations. In the case of the ear, the complicated internal-ear structure is not only for the purpose of lowering the threshold of audition, but according to the mechanical resonance theories of pitch perception, it is also for the purpose of making possible the phenomenon of this perception. It is here claimed that data which have now been collected show that these resonance theories are untenable. It is believed that the results seem to show that the sole purpose of the mechanical structure of the internal ear is to lower the threshold of audition and that the power of pitch perception is a property of the nerves including their endings. According to this view, then, the power of pitch perception is in no way associated with the actual mechanical structure of the cochlea.

E. H. B.

184. *The Geophone.* **A. Leighton.** (Bureau of Mines, Techn. Paper No. 277 [33 pp.], Washington, 1922.)—The Geophone is a non-electrical instrument for detecting and estimating the direction of sounds coming through the earth. It was developed by the French for war purposes and has since been improved and applied to mining work in America. The apparatus consists of a small round case containing two diaphragms connected together at the centre and to a lead weight between them which acts on the principle of the seismograph, tending to remain stationary while the case vibrates according to the tremors of the earth with which it is in contact. This relative movement between the diaphragm and the case causes variation in the pressure of the air in the part of the case connected to the ear tube. By using a separate instrument to each ear and applying them to the earth at points a little distance apart, the direction from which the sound is proceeding may be estimated with a surprising degree of accuracy, owing to the physiological action of the ears which depends upon the difference in phase of the waves reaching the two ears. By cross bearings taken in this way from more than one point the actual position of the sound source can be plotted. The practical applications include mining rescue and prospecting work, guiding of tunnels together, locating mine fires, faults, etc., and finding the position of leaks in water pipes.

S. R. R.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

185. *Dynamics of the Electron in an Anisotropic Medium.* **F. Massardi.** (N. Cimento, 23. pp. 247–302, May–June, 1922.)—I. (*a*) The electric and magnetic field produced by motion of the electron; (*b*) the degrees of freedom of a rigid electron; (*c*) the fundamental dynamical equation, from the principle of virtual work. II. Shows that the conservation of energy applies, and that there is an electromagnetic energy when the electrons are distributed in the medium with a finite density. III. The principle of virtual work leads to tensions on the bounding surface of the field, and to the equality of action and reaction; the effects of non-homogeneity and of anisotropy are brought into view. IV. Assuming the electron to be at rest at the initial instant, the surface-integrals at infinity vanish; a principle analogous to that of d'Alembert is arrived at, and equations of motion of the electron are reached, which are identical in form with ordinary equations of momentum and moment of momentum of rigid bodies. V. Transform the fundamental equations to axes travelling and rotating with the electron; we find electric and magnetic fields stationary with respect to the mobile axes. VI. Find the conditions, as to non-homogeneity and anisotropy, under which uniform translation of an electron may give rise to a stationary field. The equations of motion apply whether the electron was or was not at rest at the initial instant. Neither an external force nor an external couple is necessary to maintain uniform translatory movement of the electron; whence the principle of inertia. A. D.

186. *An Experiment on Molecular Gyroscopic Action.* **J. W. Fisher.** (Phys. Soc., Proc. 34. pp. 177–180; Disc., 180, Aug., 1922.)—Starting from the inference, pointed out by O. W. Richardson on the basis of electron theory, that the magnetisation of a substance implies a moment of momentum about the axis of magnetisation, the consequences of applying a rotating magnetic field to a specimen of magnetic material are analysed. It is shown that magnetisation, in a direction transverse to the plane of the rotating field, should result, in sense related to the direction of rotation of the field by the left-hand screw rule; and proportional in intensity to the first power of the angular velocity of the field and the susceptibility of the material. Experimental tests were made, using a magnetometer, but without success, disturbing effects having not as yet been eliminated. AUTHOR.

187. *The Stress-Energy Tensor in Electromagnetic Theory, and a New Law of Force.* **H. Bateman.** (Phys. Rev. 20. pp. 243–248, Sept., 1922.)—By suitably modifying the equations for the components of the stress-energy tensor it is possible to reconcile electromagnetic theory with the idea of non-radiating electronic orbits. The change, however, is equivalent to assuming that an element of electricity is acted upon by a new force which depends on the gradient of the density of electricity and balances the usual electromagnetic force. By assuming a certain distribution of density within an electron it is also possible to account for the existence of discrete electronic charges. AUTHOR.

188. *Electric Field of a Magnetised Spheroid Rotating about the Axis of Magnetisation.* **O. Rognley.** (Phys. Rev. 19. pp. 609–614, June, 1922.)—On certain assumptions, and, taking the axis of symmetry as both the axis of rotation and the direction of magnetisation, formulæ are derived for the potential at any point on the surface or outside of it (*a*) when the spheroid is insulated and uncharged as a whole and (*b*) when the axis is kept earthed. AUTHOR.

189. *Electromagnetic Waves in Absorbing Media.* **L. Page.** (Phys. Rev. 20. pp. 166–173, Aug. 1922.)—*Specific Intensities of Radiation in Two Media in Thermal Equilibrium.*—If the media are transparent, the specific intensity of radiation K is proportional to the square of the index of refraction, as was shown by Kirchhoff. In dealing with absorbing media Planck assumes that K is proportional to the square of the real part of the complex index. The mathematical investigation of the problem given in this paper confirms Planck's assumed proportionality in the case of moderately absorbing media. In intensely absorbing media it is doubtful if it is legitimate to substitute trains of plane waves of equal intensity moving in all directions for the irregular fluxes due to emission and absorption in the medium. Equations are derived for the energy reflected and the energy transmitted. AUTHOR.

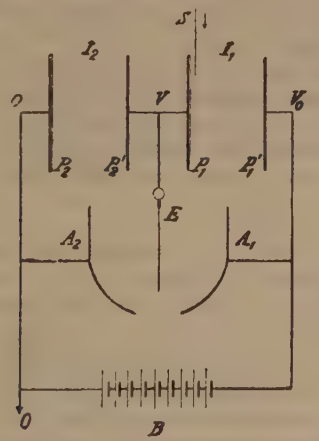
DISCHARGE AND OSCILLATIONS.

190. *The Decrease of Energy of α-Particles on Passing through Matter.* **G. H. Henderson.** (Phil. Mag. 44. pp. 680–688, Oct., 1922.)—The equation of motion of an α-particle passing through matter is developed, making use of the concepts of resonance and ionisation potentials. The equation is found to give good agreement with experiment in the case of air, but does not furnish a decisive test when compared with other solutions which have been proposed. A. D.

191. *The Existence of High-Mobility Ions in Air.* **O. Blackwood.** (Phys. Rev. 20. pp. 499–504, Nov., 1922.)—Contrary to the conclusions of other observers, Nolan has reported what he believes to be indications of the presence in ionised moist air of ions of eight different mobilities ranging from one to seven times the normal value. A repetition of Nolan's experiment, however, with duplicate apparatus, has led to an explanation of his anomalous results. In his experiment, ions generated in a small shielded space next the lower plate of a long condenser, are carried by an air current into the electric field where the mobility is determined by a blast method. At first curves similar to Nolan's were obtained, but the irregularities interpreted as due to different groups of ions were removed when precautions were taken to insure a uniform blast of air. When certain precautions were adopted, the mobility came out normal. AUTHOR.

192. *A Differential Ionometer.* **H. Greinacher.** (Schweiz. Elektrot. Verein, Bull. 13. pp. 356–365, Aug., 1922.)—In this instrument I_1 and I_2 are two ionising chambers in each of which there are two oppositely arranged plates P_1, P'_1 and P_2, P'_2 respectively (see diagram). The plates P_1 and P_2 are coated with a radio-active substance. A voltage V_0

from a battery is applied to the two chambers connected in series. The electroscope is of the Hankel type, so that the side plates A_1, A_2 are under the same voltage as the plates bounding the chambers I_1 and I_2. In order to adjust the instrument a movable screen S is provided for covering more or less of the radio-active surface in one of the chambers. In order that the electroscope leaf shall be stable, the side plates A_1, A_2 are curved towards each other at their lower parts, as shown. The instrument is applicable to the measurement of the dust in air since the ionic current is influenced thereby. The theory of the instrument is discussed mathematically. The battery used for producing the voltage across the side



plates may be replaced by a transformer and rectifier which enable a d.c. voltage of 500 volts to be obtained from a 105-volt a.c. lighting circuit. The paper includes a description of a constructional form of the instrument, in which cylindrical ionising chambers are arranged at the top with their axes vertical. C. A.

193. *On the Negatively Charged Particles in the Positive Ray Tube.* **M. Ishino** and **B. Arakatsu.** (Kyoto Coll. Sci., Mem. 4. pp. 355–358, March, 1921.)—J. J. Thomson found no evidence of the existence of molecules with a negative charge ; but the authors observed a parabola due to negatively charged molecules of H_2O, when gaseous H_2O_2 was contained in the tube. With CS_2 the parabolas of SO^- and SO_2^- were observed, and with HNO_3 that of NO^- appeared. In some cases a trace of CN^- was observed. Attention is called to the fact that the molecules and radicles SO, SO_2 and NO are very active chemically, and strongly electronegative. The photographs show that the maximum kinetic energy of these negatively charged particles is the same as that for the corresponding positive ones ; and it appears that they originally attain their velocity as positive particles, while moving through the intense electric field from the anode to the kathode, after passing through which they capture electrons, and each gains a negative charge. In some cases there is evidence, from the position of " beads " on the parabolas, that each of the negative particles producing them had a double positive charge when they moved from the anode to the kathode, and that this was replaced, after they passed through the kathode, by a single negative charge. Some of these

doubly charged particles apparently lose only one positive charge, and are deflected to the positive side of the plate to a symmetrical position; while others retain both their positive charges throughout, and form separate parabolas, for which the value of e/m is twice that of the singly charged particles. These phenomena have been observed in the cases of C, O, S, and the two isotopes of chlorine. [See Abs. 217 (1923).] In the cases of H^-, O^-, and Cl^-, some of the particles have half the velocity of the main swarm, forming a bead on the parabola the distance of which from the vertical line through the origin is twice that of the main bead. The beads due to the corresponding atoms with positive charges occur, associated with these, on the positive side of the plate. A molecule with a single positive charge would attain half the velocity, in the discharge chamber, of that of a positively charged atom and if this split up into ions, with opposite charges, after passing through the kathode, the observed appearances would be produced. The parabolas due to H^-, O^-, Cl^-, and S^-, are sometimes accompanied by secondary lines. These are probably due to particles, which are only charged during part of their passage through the deflecting electric and magnetic fields. H. N. A.

194. *On the Ageing Effect in the Mobility of Positive Gas Ions.* **H. B. Wahlin.** (Phys. Rev. 20. pp. 267–271, Sept., 1922.)—The mobility of positive ions of air immediately after formation has been found by Erikson, using a modified Zeleny method, to be much higher than the normal value. This result has been verified by the author using the alternating potential method. Ions formed in an ante-chamber by α-rays from polonium were driven by a weak auxiliary field into the measuring chamber where the mobility was determined by the use of an alternating field of 1800 to 3600 cycles and of variable strength. Pure dry air was used at a pressure of 30 mm. When the auxiliary potential was 1·5 volts the measured mobility was normal, but when the potential was 3·0 volts or more the mobility rose to 1·80 cm./sec./volt/cm., indicating that the ions entered the measuring chamber before they were aged. The time required for the ions to age or reach the normal condition is estimated to be between 1/75 and 1/120 of a second. AUTHOR.

195. *The Mobilities of Electrons in Hydrogen.* **L. B. Loeb.** (Phys. Rev. 20. pp. 397–404, Nov., 1922.) Electron mobilities in pure hydrogen have been measured for pressures of 73 to 635 mm., using a modified alternating field method with fields up to 70 volts/cm. Undamped oscillations of 15,000 to 200,000 cycles were obtained from a vacuum tube oscillator and were measured with a precision wave-meter. By using a constant retarding potential of 6 volts the disturbing effect of ions of impurities was eliminated and curves without the usual feet were obtained. The mobility (reduced to a pressure of 76 cm.) is found to be best represented by the equation: $k = 2{\cdot}74 \times 10^6/[399 + (V_0/d)(760/p^{3/4})]$, where V_0/d is the critical field in volts per cm. and p is the pressure in mm. This equation is practically of the same form as that found by less accurate measurements for nitrogen, and since it differs from Townsend's theoretical equation: $k = a/[b + (V_0/d)(760/p^{1/2})]$, either the mean free path of the electron or its loss of energy at impact are probably functions of the velocity of the electron. When the electrical fields are small the mobility at atmospheric pressure comes out at 68·6

m./sec., whereas the kinetic theory gives 130·6; hence the actual mean free path must be only about half that assumed by the theory.

AUTHOR.

196. *The Energy Losses Accompanying Ionisation and Resonance in Mercury Vapour.* **J. A. Eldridge.** (Phys. Rev. 20. pp. 456–475, Nov., 1922.)—To make possible a direct determination of the distribution of electron energies after impact with vapour molecules, a special tube was constructed in which the usual grid was replaced by two diaphragms each pierced with only a single hole. These divide the tube into two chambers which can be maintained at different pressures, the one in which the collisions take place being kept at a sufficiently high pressure and the other, in which the energies of the electrons after the collisions are measured, at a very low pressure by the use of liquid air. The source of electrons was an oxide-coated platinum foil heated by radiation from a tungsten filament, and energy distribution curves were obtained for a given accelerating potential by recording the electron current as a function of the retarding potential. These curves show that below 4·9 volts the collisions are elastic but that at higher voltages energy losses of 4·9, 5·7, or 6·7 volts may occur. For example, with an accelerating field (corrected) of 9 volts, breaks occur for retarding potentials of about 2·3, 3·3, and 4·1 volts, the curve being approximately horizontal between breaks. When ionisation is produced, however, the electron loses all its energy, even though this much exceeds the ionising potential, 10·4 volts, and the electron freed by the ionisation also seems to have practically no energy. The 6·7-volt type of radiating collision is not probable unless the energy of the colliding electron exceeds 8·5 volts, but it becomes far more prominent than the 4·9-volt type above 10 volts. The observed radiating potentials correspond to the known absorption lines λλ2536 (4·9 volts), 2330 (5·3), 2140 (5·9), and 1849 (6·7). Apparent discrepancies between these results and photoelectric data are discussed, but the explanation is not yet clear.

AUTHOR.

197. *The Variation of the Residual Ionisation in Air with Pressure, for a Range of 57 Atmospheres.* **K. M. Downey.** (Phys. Rev. 20. pp. 186–193, Aug., 1922.)—The present work is an extension of previous experiments in which a linear relation was found between rate of ionisation and pressure up to 22 atmospheres. Essentially the same method and apparatus was used as before. [See Abs. 466 (1921).] A closed steel vessel, 1 ft. in diameter, was used. Results for air from 9 to 17 days old are given in curves. From 2 to 27 atmospheres, the rate of ionisation increased linearly with the pressure at the rate of about 1·25 pairs of ions per c.c. per second per atmosphere change of pressure. Between 27 and 47 atmospheres the curves differ somewhat, the slope seeming to decrease with age, but above 47 atmospheres all curves are approximately horizontal, that is, the ionisation was found to be practically independent of the pressure from 47 atmospheres up to the highest pressure tried. In view of the theoretical conclusions already established by Professor Swann, this result clearly proves the ionisation due directly or indirectly to the action on the air of a penetrating cosmical or other radiation is extremely small, less than 0·1 pair of ions per c.c. per second at any pressure. Of the ionisation produced at atmospheric pressure, about 1·25 pairs per c.c. per second must be due to radiations, either primary or secondary, coming

from the walls of the vessel and having penetrations of from 28 to 47 ft. in air at atmospheric pressure; the rest must be due chiefly to much softer radiation, also from the walls.

Ionisation Due to the γ-Rays of Radium in Air.—A curve obtained with 2 mg. of lead-shielded RaBr placed 8 feet from the vessel, shows a slope which constantly decreases as the pressure increases, the slope at 50 atmospheres being about one-eighth of the slope at one atmosphere. Evidently most of the ionisation is due to secondary radiation from the walls. AUTHOR.

198. *Nature of the Negative and Positive Ions in Air, Oxygen, and Nitrogen.* **H. A. Erikson.** (Phys. Rev. 20. pp. 117–126, Aug. 1922.)—(1) *Mobilities just after formation* were measured by using a modified form of Zeleny's blast method. Ions produced in air by polonium rays were drawn immediately by a current of 470 cm./sec. into one side of a cross field of 130 volts/cm. and the distance they were carried along before they were dragged to the other side by the field was determined. When the average age of the ions was about 0·03 sec. the mobility was found to be the same for both positive and negative ions and equal to that for normal negative ions, about 1·89 cm./sec./volt/cm. As the age was increased to 0·5 sec., however, the positive mobility decreased to its normal value, about 1/1·40 times the negative mobility. The same results were obtained with dry commercial oxygen and nitrogen, except that the ageing of the positive ion was more rapid in oxygen. (2) *Nature of the Ions.*—In explanation of the above results it is suggested that the negative ion and the initial positive ion are each one molecule in size and that the permanent positive ion is two molecules in size. This suggestion agrees with the view that when ionisation occurs an electron is ejected from a molecule, leaving a positively charged molecule, an initial positive ion, which does not immediately acquire the second molecule needed to form a permanent positive ion. The electron attaches itself to a molecule and forms a permanent negative ion. It is also shown that the observed ratio of the mobilities for ions with one and two molecules respectively agrees with that compound according to the small ion theory of Wellisch. AUTHOR.

199. *Phenomena in Gases Excited by Radio-Frequency Currents.* **E. O. Hulburt.** (Phys. Rev. 20. pp. 127–133, Aug., 1922.)—The investigation refers to undamped radio-frequency vacuum discharges through hydrogen, oxygen, and air: (1) The spectra, 5000-3500 Å., were found to be the same for frequencies of 3×10^5 to 4×10^6 as for 60 cycles, with currents of the same strength. (2) The minimum discharge potentials for electrode distances from 5 to 30 mm. and pressures of from 1 to 5 mm. of mercury were also found to be independent of the frequency and the same as for direct currents. A theoretical discussion of this result leads to the conclusion that the discharge is initiated by collisions of electrons, rather than of gaseous ions, with gas molecules. (3) Persistence of each discharge was studied with the aid of a mirror rotating 200 times per second. Damped discharges with a frequency of 10^6 cycles or less showed separate flashes, but those with higher frequencies were blended together. This difference may, perhaps, be due to the limitations of the apparatus used. With damped oscillations the colour of the discharge changed with the voltage, as would be expected. AUTHOR.

200. *Electrical Conduction Across Minute Air-Gaps.* **J. W. Broxon.** (Phys. Rev. 20. pp. 476–485, Nov., 1922.)—Two optical surfaces of nearly the same curvatures were made conducting by depositing gold upon them by kathode discharge and were supported so as to be nearly in contact. Then, as the upper one was semi-transparent, the distance apart was determined by the interference rings produced by light of wave-length $0{\cdot}546\,\mu$. Using voltages of from 1·5 to 60, the minimum distance at which no conduction took place and the maximum distance at which conduction occurred were observed. Both these distances varied from less than a wave-length to several wave-lengths. In some cases the resistance of the gap during conduction was measured; it was found to obey Ohm's law and to be unaffected by radiation from 3 mg. of radium. The results suggest that the conduction was due to small projections from the electrodes or to dust particles. No disruptive discharge took place even when the potential gradient rose to 640,000 volts/cm., probably because the potential was less than the minimum which previous researches had indicated is necessary. Existence of electron atmospheres at metallic surfaces, which was suggested by R. W. Wood [Abs. 865 (1913)] to explain his experiments, seems very doubtful in view of the above results. At any rate, the atmosphere cannot extend more than one-fourth wave-length or $0{\cdot}14\,\mu$ beyond the molecular surfaces of the gold electrodes.

AUTHOR.

201. *Characteristics of Highly Sensitive Discharge Points.* **J. Zeleny.** (Phys. Rev. 19. pp. 566–571, June, 1922.)—*Discharge from Sensitive Points as a Function of Applied Voltage.*—The points were prepared by grinding sewing needles to a fine point and then holding them an instant in an alcohol flame. The discharge always starts impulsively and the voltage at which this occurs, if gradually increasing potentials are applied, may differ greatly on successive trials, but is never below a value B for a given point. A current once started persists when the voltage is lowered below B but breaks suddenly at a definite potential C. If a voltage above B is *suddenly* applied to a point a current will eventually start after a time interval which on the average is the shorter the higher the voltage applied.

Voltage Range for Counting Rays.—The entrance of each alpha particle or other "ray" along the axis of a counting chamber containing a sensitive point gives rise to a momentary discharge, provided the voltage used is above a limit A and below B. If the voltage is above B a continuous current is started. In a case cited A, B, and C were respectively 1730, 1875, and 1820 volts.

Explanation.—The sensitiveness of points is determined by a compact layer of gas molecules which offers a large resistance to the passage of ions, but which may be penetrated and dissipated by ions with high speeds. The initiation of a discharge is ordinarily dependent upon the fortuitous entrance of a "ray" into a region, near the point, whose extent increases as the voltage used increases.

AUTHOR.

202. *Repulsion between the Poles of the Electric Arc.* **A. Sellerio.** (Phil. Mag. 44. pp. 765–777, Oct., 1922.)—Revision of the author's paper of 1916 [Abs. 714 (1916)] in the light of Duffield's paper of 1919 [Abs. 606 (1920)]. Critical discussion of the results reached by the author and Duffield respectively.

A. D.

203. *The Unilateral Dynamic Characteristics of Three-Electrode Vacuum Tubes.* **J. G. Frayne.** (Phys. Rev. 19. pp. 629–651, June, 1922.)—(1) *Theoretical Equations when the Plate Circuit Includes Resistance, Inductance, or Capacity.* For the case of pure resistance (R), the Van der Bijl parabolic relation between plate current and effective grid voltage is expressed as a power series in $e \sin pt$, the impressed simple harmonic grid voltage. The *coefficients of the various harmonics* involve R, the *n*th harmonic reaching a maximum value when R equals $(n-2)/3$ times R_0, the tube resistance. For the fundamental the *maximum energy output* for a given plate battery is secured when $R = 0{\cdot}81\,R_0$. The dynamic characteristic was obtained by compounding the harmonics into a single curve; it approaches a straight line as the resistance is increased. For the case of pure inductance, the plate current is expressed as a Fourier series. The dynamic characteristic is a closed loop whose area is proportional to the energy in the inductance. This loop reduces to an ellipse for small values of e, in which case the tube functions as an alternator whose internal impedance is a function of the external load. The insertion of a condenser instead of an equivalent inductance gives identical results except that the phase angle of the various harmonics is shifted. (2) *Experimental Verification.*—The effects on the plate current of varying the alternating grid voltage e, the static grid voltage E_c, and the plate voltage E_b, for a given value of resistance R, or inductance l, and the effect of varying R or l with constant E_b, E_c, and e (15 or 20 volts), were determined and are shown in curves together with the corresponding theoretical values. A Western Electric 205B tube was used. The results show that the equations predict the harmonic constituents of the plate current as high as the fourth, for values of e up to 15 or 20 volts (depending on E_b), the range for which the fundamental equation holds. For this range the coefficients of the various harmonics in the equation are proportional simply to e^n. The fundamental becomes greater, while the other harmonics diminish as we approach the straight portion of the static characteristic and as we increase the plate potential.

Pure Resistance for High Frequencies.—*A platinised quartz fibre* (diameter 0·01) with a resistance of 100 ohms per inch will carry 0·06 ampere when immersed in acid-free paraffin oil and has a negligible skin effect.

AUTHOR.

204. *An Experimental Investigation of the Dispersion of a Limited Wave Train.* **I. H. Solt.** (Phys. Rev. 20. pp. 513–525, Dec., 1922.)—*Dispersion by a Prism of a Limited Train of Hertzian Waves, 7·8 and 9 cm. Long.*—According to the theory developed by Sommerfeld, Brillouin, and Colby, some energy should be propagated through the prism undeviated, the proportion decreasing as the angle of incidence is increased. This conclusion has now been experimentally confirmed. To insure a large number of short wave trains, a pliotron circuit adjusted to a frequency of 170,000 cycles was used to energise a modified Righi vibrator consisting of two steel balls suitably mounted close together. The waves so generated were sent as a parallel beam through an opening in a wall to a 30° pitch prism, and the energy as a function of the angle of deviation was determined by means of a molybdenite crystal detector, in series with a sensitive galvanometer, placed at the focus of a parabolic mirror. Various possible sources of error were eliminated or corrected for. The undeviated energy

was found to decrease from 26 per cent. for 0° incidence to 8 per cent. for 35° incidence in general agreement with the theory.

Index of refraction of pitch for Hertzian waves, 7·8 cm. long, was found to be 1·99. AUTHOR.

205. *The Velocity of Electrical Oscillations and the Measurement of Wave-Lengths.* **A. Turpain.** (Rev. Gén. d'Él. 12. pp. 511–512, Oct. 7, 1922.)—It is stated that the degree of precision of commercial wave-meters is not greater than 1 %. Abraham and Bloch have described experiments to determine the absolute value of the time of oscillation of high frequencies. They used a tuning fork of frequency 1000 and a chronometer. The source of electrical waves was so chosen as to have dozens of harmonics of frequencies corresponding to the usual electrical waves, so that the 50th harmonic corresponded to a frequency of 50,000 or a wave-length of 6000 metres. These experimenters stated they could measure wave-lengths to less than one-tenth of a thousand of the period of the tuning fork. The present writer points out that whilst the period was measured to 1 in 1000 to determine the wave-length, this time must be multiplied by the velocity of light, and in so doing the accuracy vanishes, and whilst the period is known to 1 in 1000 the accuracy of the wave-length is only known to 1 in 200. The author concludes by pointing out the great variation in the values of the velocity of light as determined by different investigators, the mean of which is used to determine wave-lengths, and refers to his own method to measure directly the actual electrical velocity by means of a rotating mirror. B. J. L.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

206. *The Resistance of Charged Thin Conducting Films.* **H. A. Perkins.** (Comptes Rendus, 175. pp. 363–365, Aug. 21, 1922.)—The method of Abs. 638 (1922) was indirect. By a direct method (Wheatstone-bridge measurement), the author finds that if the electrons of the superficial electrostatic charge play the same part as the conductivity-electrons, these latter must be at least four to each atom of gold. A film of graphite acts peculiarly; the resistance is greater when the electrostatic charge is negative, less when it is positive. The effect of X-rays, if there be any, is too small for measurement. A. D.

207. *The Variation of Metallic Conductivity with Electrostatic Charge.* **F. Wenner, N. L. Forman,** and **A. R. Lindberg.** (Phys. Rev. 20. pp. 589–593, Dec., 1922.)—Last year Perkins reported a positive result. His experiment has been repeated, using a fine copper wire, 0·08 mm. in diameter, in series with a sensitive galvanometer, as the insulated secondary of a transformer. The galvanometer was found to read the same whether the potential of this wire was + 6000 volts or − 6000 volts with reference to the primary which was earthed. This negative result shows that the resistance of this wire is changed, if at all, by not more than one part in five million even when the potential gradient at the surface is raised to about 150,000 volts (root mean square value) per centimetre. AUTHORS.

208. *Effect of Adsorbed Gas on the High-Frequency Resistance of Copper Wire.* **A. Bailey.** (Phys. Rev. 20. pp. 154–165, Aug., 1922.)—This

resistance is known to be greater than would theoretically be expected if the surface layers had the same resistivity as the core. The experiments described were undertaken to determine whether this increased resistance is due to gas adsorbed by the surface layer of oxide. A square loop, 60 cm. on a side, was formed by enclosing copper wires inside glass tubes connected to a vacuum pump, and after several hours' preliminary heating and pumping, the wire was glowed, and then its resistance for radio-waves of 20 metres' length was found to increase in 20 minutes by several per cent., though the residual pressure was only 10^{-5} atm. After successive glowings the effect became progressively less as the oxide layer disappeared. With higher pressures the increase to an equilibrium value came more rapidly. These results indicate that the gas adsorbed by the copper-oxide layer does increase the resistance, and suggest that possibly copper wire whose surface is covered with a thin layer of metal such as tin, might have a lower high-frequency resistance than oxidised copper wire of the same size.

Adsorption of Gases by Copper Oxide and Copper.—The observations indicate that copper oxide readily adsorbs gases at room temperature and liberates them when glowed, while copper does not.

An arc-type diffusion pump is described, having an iron wire ballast resistance wound around the tube which conducts the vapour to the condensation chamber. This enables the pump to get into operation quickly. AUTHOR.

209. *Hall Effect and Specific Resistance of Silver Films.* **G. R. Wait.** (Phys. Rev. 19. pp. 615-622, June, 1922.)—In agreement with previous results, the specific resistance increased more and more rapidly with decreasing thickness, becoming infinite for about 20 $\mu\mu$. On the other hand, the Hall coefficient was found to be the same in the films as in the bulk metal. The thicknesses were computed from the weight of silver in each film, assuming the density to be that of the bulk metal. The films were obtained by chemical deposition. After discussing various proposed theories in the light of the above results, it is concluded that these and other facts are in harmony with the simple conception that the film consists of granules, each having the properties of the bulk metal, and that conduction occurs only along strings of granules in contact.

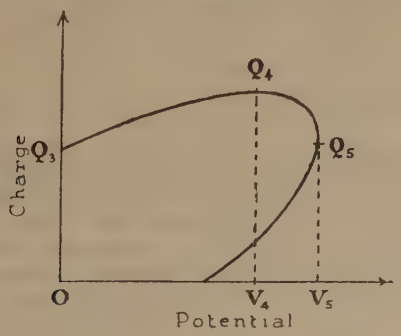
Brashear Method of Depositing Silver Films.—Exceptionally hard films whose resistance, instead of decreasing, increased slightly with time, were obtained by using about four times the amount of sodium hydroxide specified. AUTHOR.

210. *The Hall, Ettingshausen, Nernst, and Leduc Effects in Cadmium, Nickel, and Zinc.* **A. E. Caswell.** (Phys. Rev. 20. pp. 280-282, Sept., 1922.)—*Transverse Magnetic Effects in Cadmium, Nickel, and Zinc.*—The Hall, Ettingshausen, Nernst, and Leduc effects were all measured for each metal on the same thin strip, which after being provided with various thermo-couples and potential wires was heated electrically in vacuum and placed in a magnetic field of 4000 to 5200 gauss. Coefficients are given for cadmium (40 to 50°), nickel (— 11 to 57°) and zinc (— 25 to 77°). The Hall and Ettingshausen effects were not found of opposite sign as has usually been observed, but both came out positive. AUTHOR.

211. *New Undamped Wave Method of Determining Dielectric Constants.* **A. P. Carman** and **G. T. Lorance.** (Phys. Rev. 20. pp. 715–718, Dec., 1922.)—A previously described method is very fatiguing, since it involves adjusting a beat tone produced by two ultra-audion circuits, to the same pitch as that of a standard tuning fork. The new method involves merely reading galvanometer deflections, and depends upon the observation that under certain conditions the relation between current in plate circuit and capacity in the oscillating circuit is linear for a limited range; therefore three current readings, corresponding to one unknown and two known capacities, are sufficient to determine the unknown. Small changes of capacity, for instance 0·01 cm. in 1000 cm., can readily be detected and measured. The accuracy of the method is practically equal to that of the standards if sufficient care is taken to keep circuit conditions constant.

Dielectric Constant for Air, Carbon Dioxide, and Illuminating Gas.—Preliminary results obtained by the above method are 1·00060, 1·00099, and 1·00077, respectively, for 76 cm. of Hg. AUTHORS.

212. *The Relation between Frequency and Losses in a Dielectric.* **Granier.** (Rev. Gén. d'Él. 12. pp. 459–466, Sept. 30, 1922.)—To test insulators over an extended scale of frequencies the author has employed



a variety of methods; two in particular are useful: the ballistic galvanometer method and Wien's bridge. With the first a cycle of viscosity can be traced, by discharging a condenser made of the dielectric, at definite instants; as the discharge may take a long time a method has been evolved in which a permanent magnet is pushed into a coil in the circuit, at such a rate as to keep the galvanometer needle practically at zero during the discharge. The magnet is removed quickly, and the swing of the galvanometer measures the original charge of the condenser. In the Nernst bridge the condenser C, in one arm, is balanced by a perfect condenser C′ shunted by a resistance r; while in the Wien bridge r is in series with C′. The current is out of phase to the same extent in both these bridges, when the telephone is silent, and $\tan\phi = C'r\omega$, Nernst bridge, and $\tan\phi = 1/(C'r\omega)$, Wien; $\omega/2\pi$ = frequency. The two values of c' are not theoretically identical; several different definitions of the capacity of an imperfect condenser being possible. With an alternating current the *instantaneous capacity* Q_t/V_t takes all values from $-\infty$ to $+\infty$ during a period, and at any instant depends on the previous history of the

condenser. The diagram shows the hysteresis cycle, the enclosed area being a measure of the energy lost in the condenser. The capacity with alternating current may be defined as Q_4/V_5, which can be measured by the ballistic galvanometer. Using this definition, Wien's method gives $1/\sin^2\phi$ times the Nernst value, for a condenser with viscosity but no leak, and also for one with leakage, but no viscosity. $\sin\phi$ does not generally differ greatly from unity. Measurements taken with paraffined paper, from frequencies less than 0·1 per sec. up to over 1000 per sec., give results which are not very different, using the galvanometer and bridge methods at the frequencies where both can be employed. The losses follow approximately the law $W = MW^n$ for two condensers tested; n being 0·4 for the first and 0·5 for one of varnished paper. These are both regarded as very bad condensers, and show the effect studied very well. The power absorbed increases much slower than the frequency; the surface of the viscosity cycle diminishing rapidly at high frequencies. Gutta-percha and dry presspahn have practically no viscous loss. n appears to be 0·78 for glass and 0·54 for moist blotting paper. The viscous losses are small with transparent mica, and paper impregnated at high temperature *in vacuo*. H. N. A.

213. *Properties of Rochelle Salt Related to the Piezo-Electric Effect.* **J. Valasek.** (Phys. Rev. 20. pp. 639–664, Dec., 1922.)—*Temperature variation of several physical properties of Rochelle salt, from* $-30°$ *to* $+30°$ C., was undertaken to determine which of them seem to be related to the piezo-electric effect; this increases rapidly between -20 and $-15°$ C. and decreases rapidly between $+20$ and $+30°$ C. In this way it was hoped to get information as to the nature of the structure underlying piezo-electric phenomena. *Refractive indices* were measured for the three principal directions for six wave-lengths from 4554 to 6500 Å. and at temperatures of -70, $-11·5$, 0, $+21·3$, and $+40°$ C. The variation with temperature, however, is linear, the average coefficient being 59×10^{-6} per degree. The *thermal expansion* between -10 and $+20°$ C. was measured by the Fizeau method for the three principal directions. The ratio of $(n^2 - 1)$ to ρ is approximately constant, in agreement with the Sellmeir formula for dispersion, and if the change in refractivity is regarded as due to the change in density, reasonable values are obtained for the constants in the Lorentz formula. The *specific rotatory power of an aqueous solution* of the salt was found to change less than 0·4′ in the interval from $+4$ to $40°$ C., giving no indication of a change in molecular asymmetry in this interval. The value obtained at 25° C. is 25·9° for sodium light, lying between the results of previous observers. The *electrical conductivity* increases only from 2×10^{-14} mhos/cm.^{3} at $-65°$ C. to $5·4 \times 10^{-14}$ at $-20°$ C. Between $-20°$ and $+30°$ C., however, it was found to depend on the direction of the current, being only half as great in one direction as in the other at 0° and at 20°, and above 20° it increases very rapidly to 5×10^{-9} at 43°. At all temperatures, however, the current was found proportional to the applied field, at least up to 10,000 volts/cm. *The reversible electro-optic rotation* was observed in the direction of the field, using transparent alcohol electrodes and plane polarised light of wave-length 5737 Å. At 20° the rotation of the α and β axes in their plane per unit field normal to them is $1·7 \times 10^{-4}$ degrees, and decreases for higher temperatures much as the dielectric constant does. The electro-

optic constant e_{41} was also computed. Although Rochelle is classed as a type of crystal that should show no pyro-electric effect, a "real" effect was observed in the $\vec{a}$ crystallographic direction as the crystal was gradually heated at a constant rate. The coefficient changes sign just below room temperature and becomes very large. *Infra-red absorption band for Rochelle salt* is computed from the constants of the dispersion formula to be at about $55\,\mu$. AUTHOR.

214. *Electric Thermometers.* **C. Bacchini.** (Elettrotecnica, 9. pp. 673–676, Oct. 5, 1922.)—The conditions for realising industrial electric thermometers of the bolometer type are theoretically studied, and two types of such apparatus as constructed by the firm of Allocchio, Bacchini & Co., are described and illustrated. The first type requires adjustment of the arms of the Wheatstone bridge: the second type is of the direct-reading type. A special 3-wire connection is required between the variable resistance and the system of the bridge resistances, battery and ammeter in order that the resistance of the connecting wires may be neglected. The constancy of the e.m.f. of the battery can be verified from time to time by inserting a given resistance in place of the variable one. This is made of nickel wire and, like the other resistances of the bridge, is of the order of 100 ohms. The scale of the direct-reading ammeter is practically uniform and is marked in degrees. These thermometers are employed for determining at a distance the temperature of transformer oil, dynamo bearings, etc. E. B.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

215. *A Self-Regulating Current Hardness Regulator for Metallic X-Ray Tubes.* **H. Küstner.** (Zeits. techn. Physik, 3. 9. pp. 274–276, 1922.)—To maintain a constant hardness of a metallic X-ray tube by means of an exhausting pump leads to difficulties of adjustment, and the present device, based upon a device used in Siemens and Halske's instruments, is intended to effect this automatically. Briefly this regulation is obtained as follows:—

As the tube becomes soft the current via the tube and its milliammeter increases. It is arranged that a small hammer periodically moves in such a manner that if the pointer of the milliammeter has exceeded a given value, the pointer is firmly pressed down by the hammer upon contacts which complete, via the pointer, a relay circuit; this actuates electrically the motor of an air pump. The pump is so set into action to exhaust the tube further until a given degree of hardness is again obtained and the current via the milliammeter decreases and a mechanical device raises the hammer to release its pointer and stops the air pump. B. J. L.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

216. *A Kinetic Theory of Adsorption.* **D. C. Henry.** (Phil. Mag. 44. pp. 689–705, Oct., 1922.)—A theory of adsorption is developed, based on the conceptions of surface action introduced by Hardy and Langmuir. A system of n equations is found, which determine the equilibrium adsorptions of n components of a mixture. The theory works well when $n = 1$. From gases, the theorem is extended to adsorption from solutions; and it is shown how the ordinary empirical formula for low concentrations, adsorption $a = k \cdot \epsilon^{1/n}$, may be deduced from the theory. A. D.

217. *On the Evidence of the Existence of Isotopes of Chlorine.* **M. Ishino.** (Kyoto Coll. Sci., Mem. 4. pp. 311–315, March, 1921.)—Thomson's crossed deflection method was used to examine the positive rays of chlorine; the vacuum in the camera part of the apparatus being made very high, the intensity of the magnetic field very large, and special Schumann plates being employed, prepared so as to make the film very thin, with as much silver in it as possible. The chlorine parabola or "line" was thus resolved into two, indicating the existence of isotopes of atomic masses 34 and 36, the first being much the fainter. These lines were also obtained with negative carriers. A line 37 appeared on the positive side, which is ascribed to the union of the second isotope with hydrogen, to form HCl; the hydride of the first isotope was not observed. The investigation was carried out in September 1919; but publication was delayed until after Aston's letter on the isotopes of chlorine appeared in "Nature," in Jan. 1920. A parabola corresponding to a mass of 72 was observed, which appears to be due to the molecule of the heavier isotope, and beads appear on the parabolas, the significance of which is explained in Abs. 193 (1923). H. N. A.

218. *Nephelectrometer.* **I. N. Kugelmass.** (Comptes Rendus, 175. pp. 343–345, Aug. 16, 1922.)—Apparatus for tracing changes in the aggregation of colloids by determining variations in the transparency. A. D.

219. *The Law of Distribution of Particles in Colloidal Suspensions, with Special Reference to Perrin's Investigations.* **A. W. Porter** and **J. J. Hedges.** (Phil. Mag. 44. pp. 641–651, Sept., 1922.)—The distribution of particles in dilute colloidal solutions is held by Perrin to follow a law analogous to that which characterises the distribution of the molecules in an atmosphere. The experiments by which this relation was deduced were, however, limited to measurements made in close proximity to the surface of the suspension. In the present work more extended measurements have been made in the case of a suspension of gamboge in water by a counting method with the Zeiss ultra-microscope. It is considered that the main factor modifying the applicability of the gas laws is the formation of aggregates between the particles and the surrounding molecules of water. Formulæ are developed to show the relation between concentration and depth. On the basis of the formation of large aggregates the formulæ give curves which agree closely with the results of measurements and tend asymptotically to constant values of concentration with increasing depth. The results of the measurements show that three distinct regions

may be recognised in the distribution. In the first, a very thin layer close to the surface—whose thickness is of the order of the range of intermolecular forces—may have a special value for the mean concentration according to the relations established by Gibbs. Secondly, a layer studied by Perrin which is less than 0·1 mm. in thickness gives a change of concentration of a suspensoid which can be calculated from an application of the gas laws. Thirdly, there is a layer of one or two mm. thickness in which a further change of concentration occurs which cannot be calculated by the gas laws. Throughout the remainder of the suspension the concentration is found to be approximately uniform. J. N. P.

220. *The Rôle of Hydrogen-Ion Concentration in the Precipitation of Colloids.* **H. V. Tartar** and **Z. J. Gailey.** (Am. Chem. Soc., J. 44. pp. 2212–2218, Oct., 1922.)—A study has been made of the effect of hydrogen-ion concentration on the precipitation of mastic and gamboge sols by acids and salt solutions. Acids cause precipitation at the same hydrogen-ion concentration regardless of the concentration of the colloid. The negative ion of the acid is without effect. Various potassium and ammonium salts precipitate the sols at the same concentration provided the hydrogen-ion concentration is kept approximately constant. The precipitating values of the salts vary directly as the concentration of the colloid at the same hydrogen-ion concentration. The stabilising or peptising effect of the ion bearing a charge similar to that of the colloidal particle has been shown to be very limited, if it exists at all.

AUTHORS.

221. *Thermal Expansion of Gelatin Gels.* **A. Taffel.** (Chem. Soc., J. 121. pp. 1971–1984, Oct., 1922.)—An accurate dilatometer is described, consisting of a glass bulb which can be closed at one end by a rubber-faced brass disc and is attached at the other to a graduated capillary tube. With its help it is shown that gelatin gels expand regularly with rise of temperature, the expansion curves being similar to that of water but flatter in proportion to the concentration of the gel; the sudden change in direction shown by the curve for glass below its melting-point does not appear in this case. The coefficients of expansion, and the specific volumes at any one temperature, are linear functions of the concentration of the gel. Hydrogen ion concentration is without effect on the coefficient of expansion. One gramme of gelatin is always associated with the same contraction in a gel at any one temperature, no matter how much water is contained in the gel; this contraction is 0·073 c.c. at 15° and 0·065 c.c. at 32°. This result indicates that only a fraction of the water in a gel is contracted, and that the contraction of a gel is not due to a filling-up of pores in solid gelatin by water. An explanation is advanced of the double flexure in the curve connecting concentrations and setting points of gelatin gels observed by Sheppard and Sweet (J. Ind. Eng. Chem. 13. 413, 1921).

Gelatin lowers the temperature of maximum density of water by an amount directly proportional to its concentration (per constant weight of water). This depression is shown to be due to the ordinary volume changes of dry gelatin with changing temperature, and to the change in the amount of contraction on imbibition of gels when the temperature varies. T. H. P.

222. *Self-Kindling of Hydrogen Jets.* **P. Pothmann.** (Zeits. Vereines deutsch. Ing. 66. pp. 938–939, Sept. 30, 1922.)—Jets of hydrogen containing water (droplets or ice-crystals) become charged, produce a visible flame-like glow, and may produce sparks as much as 70 mm. in length. This accounts for certain accidents which have recently happened. A. D.

223. *Ignition of Gases.* II. *Ignition by a Heated Surface. Methane-Air Mixtures.* **W. Mason** and **R. V. Wheeler.** (Chem. Soc., J. 121. pp. 2079–2091, Oct., 1922.)—When a gas mixture is introduced into a heated vessel, the volume of gases cannot at once be heated to the temperature of the walls, the local composition may change in the interval, and there is loss of heat to and through the walls. Yet this method of Mallard and Chatelier was used by the authors because their main object was to determine the most readily ignited mixtures rather than the true ignition temperature (i.t.). The mixtures are rapidly admitted into an evacuated cylinder of quartz of 81 cm.^{3} capacity, electrically heated; the lowest wall temperature causing ignition is accepted as the relative i.t. This i.t. decreases as the size of the vessel increases, especially with walls (metallic) of high catalysing power; smooth quartz is a poor catalyst for methane combustion. Mixtures containing 5 or 6 % of methane are found to be most sensitive to ignition by hot quartz; the most explosive mixtures (9·5 to 10 %) are more difficult to ignite. The pre-flame period, the time-lag interval in which the i.t. is reached, has to be considered. This time-lag amounts to 10 to 15 seconds (with the walls at the relative i.t.); it is shorter when the walls are at higher temperature, and smaller also in the presence of an excess of oxygen. When the gas flows over a heated surface, a minimum time of contact of 1 second seems to be required for ignition. In the experiments a pressure-recording device is used and the ignition lag is deduced from the pressure curve. When the vessel is charged with nitrogen after each experiment, the catalysing power of the quartz and the i.t. remain unaffected, apparently for two years; when air is admitted, the i.t. observed is lowered. For Part I, see Abs. 101 (1921). H. B.

224. *The Dicyclic Colour Theory and the Structure of the Nitrogen Atom.* **J. Moir.** (Chem. Soc., J. 121. pp. 1808–1813, Sept., 1922.)—On the basis of a theorem by W. N. Roseveare (Pietermaritzburg) as to the elliptical path of an electron round two atoms at the foci of the path, the author develops an explanation of the colour data in methylene-, imino-, oxo-, and thio-groups, and calculates the angles between the valencies of tervalent nitrogen. A. D.

225. *Positive-Ray Analysis of Potassium, Calcium, and Zinc.* **A. J. Dempster.** (Phys. Rev. 20. pp. 631–638, Dec., 1922.)—Isotopes of potassium, calcium, and zinc have been determined by positive-ray analysis, using the apparatus and method previously described in which the charge deflected by a constant magnetic field through a fixed slit into a Faraday cylinder is measured as a function of the voltage accelerating the rays. Curves showing maxima corresponding to the various isotopes are reproduced. With potassium, isotopes with atomic weights 39 and 41 were found as previously observed by Aston. With pure calcium, isotopes at 40 and 44; and with zinc, isotopes at 64, 66, 68, and 70 were observed. After a disturbing effect of the electric field was eliminated, the ratio of the intensities obtained, 18 to 1 for the two isotopes of potassium and

70 to 1 for those of calcium, gave average atomic weights agreeing well with accepted values, 39·10 and 40·07 respectively. It is pointed out that when the determination of the relative proportions of all the isotopes of an element is made sufficiently accurate and reliable, a comparison between calculated and observed average atomic weights would give a measure of the packing effect or divergence of the weights of the isotopes from integral values. If the width of the slit used in limiting the beam of canal rays were reduced from 0·37 to 0·07 mm., isotopes of elements of atomic weight 100 or more should be resolved with the present apparatus.

AUTHOR.

226. *Thermal Analysis at Low Temperatures.* **F. E. E. Germann.** (Phys. Rev. 19. pp. 623–628, June, 1922.)—*Cooling and Heating Curves for Water Solutions of Uranyl Nitrate between* 0° *and* − 70° C.—A thermo-junction was placed in 0·5 c.c. of a solution of known concentration and galvanometer readings were taken every 10 seconds during the cooling. At about − 35° a rapid evolution of heat took place accompanied by expansion sufficient to break the glass tube if the solution filled more than the rounded bottom. On heating the solution a corresponding absorption of heat was observed at − 20°. From the observed temperature changes and the specific heat the amount of heat evolved or absorbed was computed. The results of 67 experiments in which the concentration was varied from 10 to 55 % were plotted and show a sharp maximum at 48·0 % for the evolved heat and at 47·5 % for the absorbed heat.

New Compound Discovered by Thermal Analysis, Uranyl Nitrate Icositetrahydrate.—The above results point to the formation at − 35° of the compound $UO_2(NO_3)_2 . 24H_2O$, which has a less density than the hexahydrate and which decomposes spontaneously at − 20°. This compound is of special interest in connection with the study of the relation between the composition and the fluorescence and absorption spectra of the uranyl hydrates.

AUTHOR.

227. *Physical Chemistry of the Lead Oxides.* III. *Hydrated Lead Monoxide.* **S. Glasstone.** (Chem. Soc., J. 121. pp. 58–66, Jan., 1922.)—The author [Abs. 1433 and 1434 (1922)] fails to confirm the existence of the oxides $3PbO.H_2O$ and $2PbO.H_2O$, but finds that the actual products are either pure substances of the formulæ $5PbO.2H_2O$ or $8PbO.3H_2O$, or solid solutions of two or more simple hydrated oxides. When the oxides are precipitated from lead salts with alkali, the amount of water seems to vary with the temperature and concentration. The substances may be regarded as lead plumbites.

IV. *Red Lead and Lead Sesquioxide.* (*Ibid.* pp. 1456–1469, Aug., 1922.)—Electrochemical studies of the affinity relation between triplumbic tetroxide (red lead) and the monoxide and dioxide, and between the sesquioxide and the simpler oxides, the experiments being, as in the following papers, carried out in sodium hydroxide solutions. Both red lead and hydrated lead sesquioxide are shown to be plumbous salts, giving plumbous ions. The sesquioxide is less soluble in alkali than the monoxide and more so than the dioxide, and can be purified in this way; there is no anhydrous sesquioxide. The normal plumbate-plumbite potential is 0·30 volt at ordinary temperatures.

V. *Electromotive Behaviour of Lead Dioxide.* (*Ibid.* pp. 1469–1480, Aug., 1922.)—The work comprised a comparison between chemical lead

dioxide and dioxide electrolytically deposited from neutral or acid lead nitrate or from slightly alkaline lead tartrate. These electrolytic products did not differ in their electromotive behaviour; but there was evidence of an unstable higher acidic oxide, possibly PbO_3, traces of which are present in solid solution in the dioxide. Lead monoxide and dioxide combine in the presence of N-alkali to form red lead; the existence of the pure hydrate H_2PbO_3 is doubtful. The maximum value of the normal plumbic-plumbous potential is 1·75 volts at 25°.

VI. *Anodic Behaviour of Lead and Lead Dioxide.* (*Ibid.* pp. 2091-2098, Oct., 1922.)—The cell consists of a platinum foil kathode and an anode of pure lead or of lead dioxide; the anode potential was measured by comparison with a standard mercuric-oxide half-element, the connecting tube of which was drawn out to fit into a pit of the lead plate. When the current density is increased, the potential drops to half its value, and a grey film creeps over the, so far, clean surface of the lead anode, the anode potential rising at the same time to 0·7 volt. After a few minutes a second black film passes over the anode, the potential rises to 1·18 volts, and oxygen begins to be evolved. The gas evolution is ascribed to the continual formation and decomposition of this second film, probably of the higher oxide PbO_3, though this oxide is only present in very small amounts; this oxide may also be responsible for the initial high electromotive force of a freshly charged accumulator. Grube had made similar observations with anodes of platinum (possibly oxides PtO_3 and PtO_4) and also of lead [Abs. 2356 (1922)]. When the H-sodium hydroxide is saturated with lead monoxide, the characteristic potentials are lower than stated above. The lead dioxide anodes are prepared by depositing PbO_2 electrolytically on platinum. Evolution of oxygen takes place at anodes of lead or of lead dioxide at almost identical potentials. Féry's theory of the accumulator [Abs. 324 (1918)] is criticised.

H. B.

228. *Some Properties of Ions in Water.* **S. Suzuki.** (Phys. Math. Soc. Japan, Proc. 4. pp. 155 161, Sept., 1922.)—The author has found there to be a numerical relationship between the ionic diameter (using values obtained by W. L. Bragg) and the number of water-molecules attached to the ion (calculated by means of Washburn's equations). An attempt is then given to explain why the hydrogen-ion of smallest dimension has only one or two molecules of water, while the lithium ion of next smallest dimension has 14 molecules of water, the explanation being based upon the atomic model of Lewis and Langmuir. According to the latter there are 2 cells around a hydrogen nucleus occupied by 2 electrons, whilst 8 cells exist around a lithium nucleus, each having capacity to hold 2 electrons even in one cell, so that 16 electrons can be found in 8 corners of a lithium nucleus. If a molecule of water be treated as an electron, or it be assumed that a certain electron in one water-molecule plays such a rôle as an isolated single electron, the reason why few water-molecules are attached to a hydrogen ion in contrast to the many adhering to a lithium ion becomes obvious. The reason also why only a few molecules of water become attached to the ions of much larger dimensions, which should have more numerous cells than the lithium ion, lies in the weakness of the electric field as the distance of molecules of water from the nucleus increases. The same reasoning applies to the hydrated negative ion, since the water-molecule has ex-

tremely high polarity. The author finally suggests a mechanism for ionisation from a relation derived from the data of the volume-changes of solutions. H. H. Ho.

229. *Solubility of Gases in Aluminium.* **J. Czochralski.** (Zeits. f. Metallkunde, 14. pp. 277–285, July, 1922.)—Gases are passed over 200 g. of fused aluminium. An absorption of gas is hardly noticeable below 900° C. and it increases as the temperature is raised to 1500°. The solubility estimates—high accuracy is not claimed—are based upon density tests, planimetric determination of gas enclosures, and partly upon analyses. The absorption of gas increases in the order: N, CO, air, oxygen, SO_2, CO_2, coal gas, hydrogen; up to 15 per cent. by volume of hydrogen is taken up at 1500°. The formation of compounds, nitride, oxide, sulphide, is allowed for. The presence of gas in the metal impairs the strength but little, but the gas-laden metal cracks when rolled and is not suitable for wire-drawing; these mechanical treatments render the gas enclosures visible. When air is blown through fused aluminium, blow-holes are not formed. Since aluminium is hardly heated above 900° in normal practice, the gas absorption would not be serious; but remelting and overheating, particularly in atmospheres of hydrogen and SO_2, should be avoided, and gas-bearing aluminium should not be worked above 350° C. H. B.

230. *Constitution of Soap Solutions. Hexadecanesulphonic (Cetylsulphonic) Acid and other Sulphonates.* **M. H. Norris.** (Chem. Soc., J. 121. pp. 2161–2168, Oct., 1922.)—Hexadecanesulphonic acid is found to be a hydrogen soap exhibiting the typical behaviour of a colloidal electrolyte in its conductivity, osmotic activity, and high-temperature coefficient of solubility. Its place is among the highest soaps, between sodium stearate and behenate. The behaviour of sodium α- and β-naphthalenesulphonates and of sodium anthraquinonesulphonate lends support to the assumption that the length of the molecule is an important factor in the production of a colloidal electrolyte; thus, the α-form is less markedly colloidal than the β-form, and the ring compounds far less so than the open-chain compounds containing the same number of carbon atoms in the molecule. T. H. P.

231. *Corrosion of Iron and Steel. Influence of Molecular Concentration on Immersion-Test Investigations.* **D. M. Strickland.** (Chem. and Met. Eng. 26. pp. 1165–1169, June 21, 1922.)—Results of a number of experiments are given carried out with commercially pure iron, commercial steel, and coppered steel at different temperatures. Samples were left in hydrochloric acid, sulphuric acid, nitric acid, aluminium sulphate, ferric chloride, and ammonium persulphate, and the extent of the corrosion was determined. W. R. C.

232. *Adsorption a Criterion of Corrosion.* **B. D. Saklatwalla.** (Chem. and Met. Eng. 27. p. 647, Sept. 27, 1922.)—The corrodibility of a solid in a gaseous atmosphere appears to depend on its ability to adsorb the gas to a greater or less pressure; in the former case the resultant increased velocity of surface interaction produces instantaneously a protective film on the surface of the metal. Further, the high-pressure gas-film, having the characteristics of a solid body, may itself act protectively without forming the secondary reaction film. As an example

of absolute non-corrodibility mention is made of tantalum, which withstands the action of boiling aqua regia for several hours; like palladium, this metal is capable of absorbing a very large volume of gas.

T. H. P.

233. *Diminution of Lag at Ar_1 through Deformation.* **J. H. Whiteley.** (Iron and Steel Inst., J. 106. pp. 89–93; Disc., 94, 1922.)—Evidence of lag in the crystallisation of pearlite, particularly in hypoeutectoid steels is abundant and indicates that ordinary lamellar pearlite is formed from a supersaturated solid solution. In the case of supersaturated liquid solutions, it is found that agitation or stirring of the liquid is sometimes effective in initiating crystallisation and thus reducing lag. Hallimond has stated that for supersaturated solid solutions, violent mechanical working may be the analogue of agitation (see next abstract). Experimental work is described designed to ascertain whether the temperature and rate of pearlitic growth could be increased through disturbances of structure caused by deformation of the steel when in the metastable condition of supersaturation. Two methods of deformation were used, namely hammering and bending which were applied at definite temperatures. The results showed that lag at Ar_1 could be diminished by slight deformation. A certain amount of lag also occurs at the Ar_3 point, but in this case no evidence of acceleration was obtained by deformation.

C. O. B.

234. *On Delayed Crystallisation in the Carbon Steels: the Formation of Pearlite, Troostite, and Martensite.* **A. F. Hallimond.** (Iron and Steel Inst., J. 105. pp. 359–378; Disc. and Corresp., 379, 1922.)—The paper deals with the application of the supersaturation theory to steel. A summary of recent researches on delayed crystallisation and inoculation is first given, after which the origin of pearlite, troostite, and martensite is discussed. The area below the eutectoid point, common to the metastable ranges for cementite and ferrite, is termed the eutectoid area, and indicates those conditions under which the growth of pearlite can occur. The causes that determine the spacing of pearlite are described. Martensite is regarded as a labile shower of *a*-ferrite and troostite as a labile shower of cementite; in the latter case the appearance of the cementite is quickly followed by the growth of *a*-ferrite due to inoculation by the cementite at a relatively high temperature.

AUTHOR.

235. *A Transition or Adsorption-Layer Theory of the E.M.F. of the Voltaic Cell.* **R. D. Kleeman.** (Phys. Rev. 20. pp. 174–185, Aug., 1922.)—Since the layer of solution adjacent to the plate is under the influence of the molecular forces of the metal plate on one side and under those of the liquid on the other, it will, in general, differ from the rest of the solution in density, in concentration of solute (adsorption), and in degree of dissociation; and because of the difference in the diffusion velocities of the positive and negative ions, a segregation of the ions will result which will produce an electric field through the layer and will also charge the plate and the solution oppositely. These two fields, one due to the asymmetrical distribution of ions (volume charge) and the other to the charge on the plate, together cause the potential difference observed between metal and solution. The theory explains the well-known phenomena of the voltaic cell and also leads to the prediction

of a number of new effects. When equilibrium exists the rates of gain and of loss of charge, by diffusion of ions to the plate and by chemical action, must be equal. This equilibrium should take an appreciable time to establish initially, it should be affected by a magnetic field and should be different if there is relative motion between the plate and the liquid. The e.m.f. of a voltaic cell should depend on the distance apart of the plates and should change when a direct or alternating current is sent through the cell; and two rods of the same metal but of different diameters should show a difference of potential when dipped in the same electrolyte. The general differential equations for the difference of potential according to this theory are given. AUTHOR.

236. *Variation of the Electromotive Force of a Weston Cell (in Quartz) under the Action of Ultra-Violet Light.* **J. Pougnet.** (Rev. Gén. d'Él. 12. pp. 514–516, Oct. 7, 1922.)—Ultra-violet light having a powerful chemical action, it is natural to imagine that it is possible for it to modify the action of a chemical cell which is really only a chemical system. A Weston cell was chosen because it is less sensitive to temperature variations and its small volume allows it to be easily submitted to the action of ultra-violet light, but as the normal glass container is opaque to such light a quartz container was constructed. After subjecting such a cell to the action of ultra-violet light from a Cooper-Hewitt lamp, its e.m.f. was always found to be above that of a similar cell in glass. An equation of correction of the voltage with charge of temperature of the cell is given and extended tables of temperature, times of exposure to ultra-violet light, and resultant e.m.f.'s.

The results are shown by exponential curves, the equations to which are discussed in the light of a balance between the chemical and electrical forces. The author shows the results are not due to mere variation of temperature of the cell, as this for the Weston cell is of the order of 1 in 10,000 whilst the results obtained are of the order 1 in 100. The various chemical reactions which occur in the cell are discussed, and the writer has noticed a greater change in the mercurous sulphate on the side of the cell exposed to the rays, a result which has been confirmed by experiments on mercurous sulphate itself, which undergoes a reversible change to mercury and mercuric sulphate. B. J. L.

237. *Passivity and Over-Potential.* **U. R. Evans.** (Faraday Soc., Trans. 18. pp. 1–13; Disc., 13–18, Oct., 1922.)—When metallic corrosion yields an insoluble product, this product may form a film or may be dispersed in the solution. That would depend upon the interfacial tension between the metal, the corrosion-product, and the solution. The author considers the phenomena as analogous to the behaviour of a powder when shaken with two immersible liquids (Reinders) and to the stabilisation of oil emulsions by pellicles of basic salts (Pickering). The films are often oxidic probably, but need not be ascribed to any three-dimensional oxides known in the massive state. Adsorbed layers of gases would suffice; the hydrogen at kathodically-polarised electrodes would be in a state intermediate between elementary and ionic, and would form a link between metal and solution, decreasing the energy of the interface. In the *discussion*, **H. Borns** referred to the influence of diffusion, and the importance of the quantitative relations and of the lattice structure, which make certain alloys unattackable in the sense of Tammann. **N. V. S.**

Knibbs would accept Newbery's definition of over-potential but not his compounds (hydrites, etc.) assumed to account for over-voltage; he referred to Günther-Schulze. H. B.

238. *The Resistance-Temperature Coefficient of Concentrated Solutions of Sodium in Liquid Ammonia.* **C. A. Kraus** and **W. W. Lucasse.** (Am. Chem. Soc., J. 44. pp. 1941–1949, Sept., 1922.)—(1) The resistance-temperature coefficients of concentrated solutions of sodium in liquid ammonia have been measured from the saturation point up to V = 5·02 and at temperatures from the boiling-point of liquid ammonia down to − 60°. (2) Near the saturation point the temperature coefficient of sodium in liquid ammonia has a value of approximately 0·066 %. With decreasing concentration it increases markedly, passing through a maximum of about 3·6 % at V = 1·1 and thereafter decreasing to about 1·55 % at dilutions above 4·0 litres per atom. Taking into account the earlier work on the temperature coefficient of more dilute solutions it is evident that the temperature coefficient passes through a minimum value. (3) The form of the curve at high concentrations shows that at these concentrations the temperature coefficient approaches a negative value, although this value is not actually realisable since the saturation point of the solution is reached. At the highest concentrations the solutions of the metals in liquid ammonia closely resemble metallic alloys. (4) At lower temperatures the temperature coefficient increases markedly at higher concentrations. The influence of temperature on the coefficient decreases with the concentration, and at a dilution V = 5·3 the coefficient is relatively independent of temperature. From previous work on the influence of temperature on the temperature coefficient of more dilute solutions it is clear that this influence changes sign, since at low concentrations the temperature coefficient increases markedly with increasing temperatures. E. F.

239. *Kathodic Hydrogen and Nitrogen at High Pressures.* **J. N. Pring** and **E. O. Ransome.** (Faraday Soc., Trans. 17. pp. 689–694; Disc., 695, May, 1922.)—Experiments to find whether in the absence of thermal effects the specific electrolytic effect caused combination between nitrogen and kathode hydrogen at high pressures gave negative results. Compare E. Tiede and A. Schleede [see Abs. 681 (1922)]. A. D.

240. *Polarisation-Capacities of Platinum Plates in Sulphuric Acid.* **A. Griffiths** and **W. T. Heys.** (Phys. Soc., Proc. 34. pp. 169–173; Disc., 174, June, 1922.)—A new apparatus for the measurement of these capacities, which, by a falling-plate method for making connections of short variable and calculable periods, enables corrections to be made for the leakage and self-depolarisation of the cell. Results are consistent to one or two per cent., and are of the same order of magnitude as those obtained by other observers. A. D.